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NEW ENGLAND DIV FEB 80

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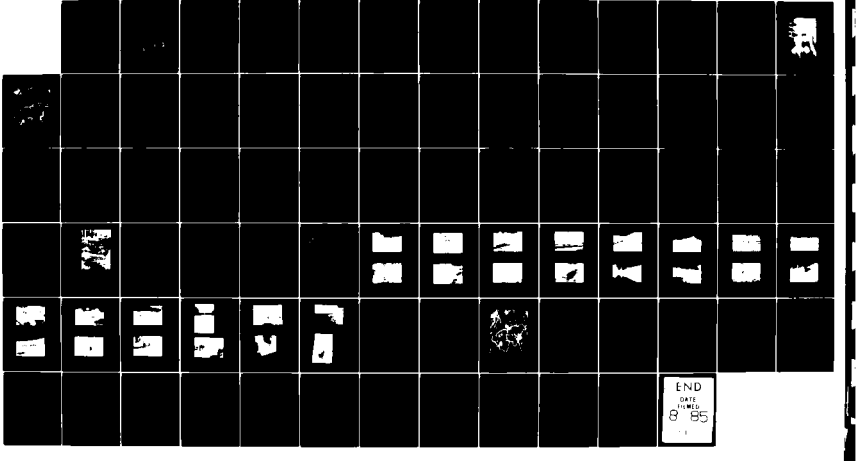

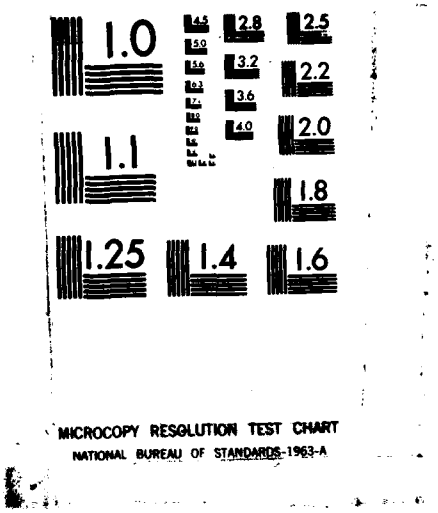
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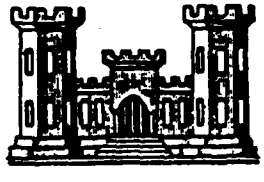
NEPONSET RIVER BASIN
CANTON, MASSACHUSETTS

BOLIVAR POND DAM
MA 00807

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

FEBRUARY 1980

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TO: Chief, Design Branch
Chief, F&M Branch
Chief, Water Control Br.

FROM: Chairman, Dam Safety Review Board

DATE 22 FEB 80 CMT 1

Attached for your review are two copies of the Architect-Engineer's draft report for Bolivar Pond Dam, Identity No. MA 00807. The review board meeting date for this report is 5 MAR. Please present your comments in writing under the format shown below. Please return one copy with your comments. Cost code for this rewiew is ABA02 070 2 00000 (FY80)

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NATIONAL PROGRAM OF INSPECTION OF NON-FEDERAL DAMS
DRAFT REPORT REVIEW COMMENTS
Bolivar Pond DAM, IDENTITY NO. MA 00807
F&M BRANCH

Page No.	Comments
Appendix C	Show area of seepage in building on photo plan.

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18. SUPPLEMENTARY NOTES

Cover program reads: Phase I Inspection Report, National Dam Inspection Program; however, the official title of the program is: National Program for Inspection of Non-Federal Dams; use cover date for date of report.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

DAMS, INSPECTION, DAM SAFETY,

Neponset River Basin
Canton, Massachusetts
Steep Hill Brook

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The dam is an earth embankment about 150 ft. long. Its size is small with a hazard potential of high. The dam appears to be in poor condition. The dam does not have a reservoir drain system. The selected test flood for the project is the full PMF. Several indications of structural cracking are apparent on both the upstream wall which is a wall of the Town of Canton DPW garage.

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BOLIVAR POND DAM

MA 00807

NEPONSET RIVER BASIN

CANTON, MASSACHUSETTS

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

NATIONAL DAM INSPECTION PROGRAM

PHASE I INSPECTION REPORT

Identification No.:	MA 00807
Name of Dam:	Bolivar Pond Dam
Town:	Canton
County and State:	Norfolk, Massachusetts
Stream:	Steep Hill Brook
Date of Inspection:	October 24, 1979

BRIEF ASSESSMENT

Bolivar Pond Dam is an earth embankment approximately 150 feet long. Both the upstream and downstream faces of the dam are vertical stone walls. Bolivar Street, which is approximately 40 feet wide, is located on the crest of the dam. The concrete overflow service spillway is located approximately 250 feet right of the dam. The drop-inlet closed conduit auxiliary spillway is located about 175 feet to the right of the service spillway. The dam was originally constructed for industrial water power. The impounded waters are now used for recreational purposes with many homes located on the shores of the pond.

The pond behind the dam is about 2,900 feet long and it has a surface area at the spillway crest level of about 23 acres. The drainage area above the dam is 20.9 square miles. The maximum storage to the top of the dam is estimated to be about 200 acre-feet and the maximum height is approximately 12 feet; therefore the size classification is "Small". A breach of the dam would have an extreme effect on the Town of Canton DPW garage immediately downstream of the dam resulting in excessive property damage and probable loss of life. Therefore, the dam has been classified as having a "High" hazard potential. Based on the "Small" size and "High" hazard potential, the range for the test flood is one-half of the Probable Maximum Flood (PMF) to the full PMF. The selected test flood for the project is the full PMF.

The dam appears to be in poor condition. Several indications of structural cracking are apparent on both the upstream wall and the downstream wall which is a wall of the Town of Canton DPW garage. About 5 gpm seepage was noted discharging from the downstream wall inside the Town of Canton garage. The dam does not have a reservoir drain system.

The test flood inflow for the facility is approximately 9,410 cfs. The routed test flood outflow of 9,405 cfs overtops the dam by 2.9 feet. The spillway system is able to pass 115 cfs or about 1 percent of the routed test flood outflow without overtopping the dam.

Within one year after receipt of this Phase I Inspection Report, the Owner, the Town of Canton, should retain the services of a qualified registered professional engineer to perform the following services:

(1) assess further the potential for overtopping and the adequacy of the spillway; (2) study the structural integrity of the dam; (3) study the cause of seepage through the dam; (4) investigate the seismic stability of the dam; (5) direct the removal of the trees adjacent to the service spillway; and (6) design a low-level outlet for emergency drawdown of the reservoir.

The Owner should also impelement the following operation and maintenance measures: (1) remove material impeding flow in the service spillway and repair the training walls; (2) remove the trees adjacent to the upstream parapet wall of the dam; (3) establish suitable vegetative cover in the area of the service spillway; (4) all spalled or deteriorated concrete should be repaired; (5) develop a formal surveillance and flood warning plan, including round-the-clock monitoring during heavy precipitation; (6) institute a program of annual technical inspection; (7) develop and adhere to a comprehensive maintenance program.

O'BRIEN & GERE ENGINEERS, INC.

John J. Williams

Date: 24 MARCH 1980

John J. Williams
Vice President
New York Registration No. 050794

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of theses guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation: however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

The Phase I Investigation does not include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be needed to minimize trespass and provide greater security for the facility and safety to the public. An evaluation of the project for compliance with OSHA rules and regulations is also excluded.

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UPSTREAM OVERVIEW OF BOLIVAR POND DAM VIEWED FROM THE
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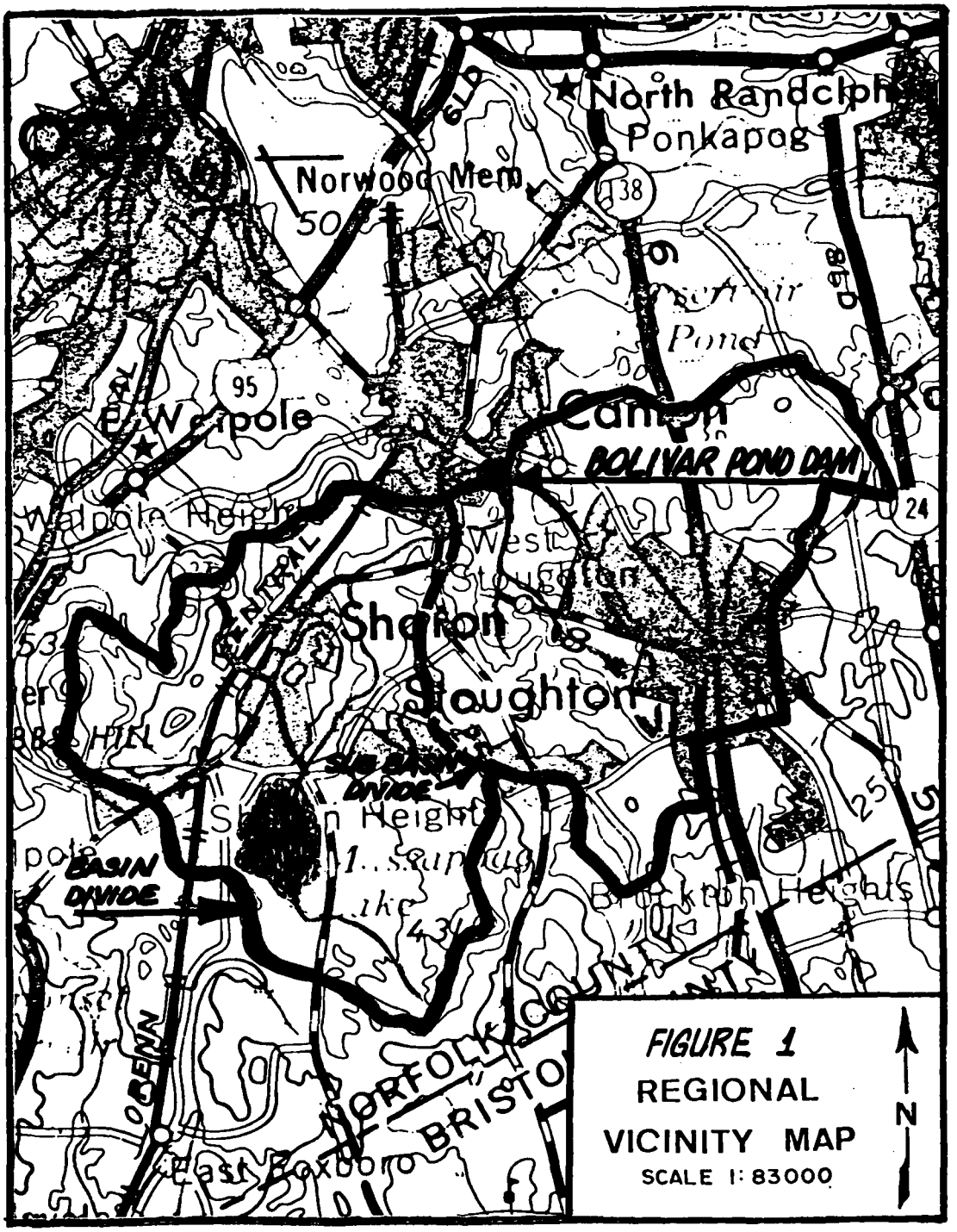


FIGURE 1
REGIONAL
VICINITY MAP
SCALE 1: 83000

NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT
BOLIVAR POND DAM

SECTION 1

PROJECT INFORMATION

1.1 General

a. Authority. The National Dam Inspection Act (Public Law 92-367), of August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate the National Program for Inspection of Dams throughout the United States. Responsibility for supervising inspection of dams in the New England Region has been assigned to the New England Division of the Corps of Engineers.

O'Brien & Gere Engineers, Inc. has been retained by the New England Disivion to inspect and report on selected non-federal dams in the Commonwealth of Massachusetts. Authorization and Notice to Proceed were issued to O'Brien & Gere by a letter dated November 6, 1979 and signed by Colonel William E. Hodgson, Jr. Contract No. DACW33-80-C-0014 has been assigned by the Corps of Engineers to this work.

b. Purpose of Inspection. The purpose of performing technical inspection and evaluation of non-federal dams is to:

1. Identify conditions which threaten public safety and make the Owner aware of any deficiencies to permit the Owner to correct them in a timely manner.

2. Encourage and prepare the states to initiate effective dam safety programs for non-federal dams as soon as possible.

3. Update, verify, and complete the National Inventory of Dams.

1.2 Description of Project (Information with regard to this dam was obtained from Mr. Daniel Therriault of the Town of Canton Engineering Division)

a. Location. Bolivar Pond Dam is located on Steep Hill Brook in the Town of Canton, Massachusetts. A portion of the USGS Quadrangle map entitled "Norwood, Massachusetts" has been included as Figure 1 on page vi of this report to illustrate the location. USGS reference coordinates for this dam are N 42°9.1' and W 71°8.4'.

Bolivar Pond discharges directly into Forge Pond which outlets into the East Branch of the Neponset River. The East Branch flows into the Neponset River about 2.5 miles downstream of Bolivar Pond Dam. The major damage center, the Town of Canton Department of Public Works (DPW) garage, is located immediately downstream of the dam.

b. Description of Dam and Appurtenances. Bolivar Pond Dam is an earth embankment approximately 150 feet long with a maximum embankment height of about 12 feet. The embankment has the following major features:

1. The upstream face of the embankment consists of a vertical stone masonry parapet wall.

2. Bolivar Street, which is approximately 40 feet wide, is located on the crest of the dam.

3. Downstream support for the dam is provided by a stone masonry wall which also serves as the foundation wall for the Town of Canton, DPW garage.

4. Two abandoned mill race conduits extend from Bolivar Pond, pass under the DPW garage and outlet approximately 300 feet downstream of the dam. In addition, an abandoned 30-inch diameter pipe from Bolivar Pond outlets into the garage. All three conduits have been plugged with concrete.

The service spillway inlet, which is located approximately 250 feet to the right of the dam, consists of two 46-inch wide rectangular openings in a one-foot thick concrete headwall. Water overflowing the stop logs in the openings discharges into an approximately 10-foot wide channel and flows in a northerly direction about 90 feet to a stone bridge under Bolivar Street. About 100 feet north of the bridge the channel discharges into Forge Pond. The auxiliary spillway located about 175 feet to the right of the service spillway consists of a drop inlet with a 270-foot long, 30-inch diameter outlet conduit. The conduit discharges into a 200-foot long, approximately 7-foot wide channel which discharges into Forge Pond. According to Mr. Daniel Therriault of the Town's Engineering Division, there is no provision for draining Bolivar Pond.

c. Size Classification. Bolivar Pond Dam has a maximum embankment height of approximately 12 feet which places it in the "Small" size category for height, because it is less than 40 feet high. It also falls into the "Small" size category for storage since its maximum storage capacity of 200 acre-feet is less than the 1,000 acre-foot upper limit for "Small" size dams. Therefore, Bolivar Pond Dam is classified as "Small" for the purpose of this inspection program.

d. Hazard Classification. The Town of Canton DPW garage is located at the downstream wall of the dam embankment. A breach of the dam would result in the destruction of the Town of Canton DPW garage. Because of the potential for loss of life and excessive property damage relative to the garage, the dam is classified as a "High" hazard potential structure.

Photos of the downstream hazard area are included in Appendix C.

e. Ownership. The dam is owned by the Town of Canton, with offices in Memorial Hall on Washington Street, Canton, Massachusetts, 02021, Telephone 617-828-3551.

f. Operator. The dam is operated under the supervision of personnel from the Town's Engineering Division, 617-828-3551.

g. Purpose of Dam. The dam was originally constructed for industrial water power. According to Mr. Therriault, the Owner's representative, the DPW garage was once part of the Ames Shovel Shop.

Currently, the primary use of the pond is for recreation.

h. Design and Construction History. According to the Owner's representative, it is believed that the dam was built sometime during the mid-nineteenth century. The DPW garage was once part of the Ames Shovel Shop which utilized the water flowing through the now abandoned races for industrial water power.

Since the time the dam was originally constructed, it appears that three major modifications have been made. The Owner's representative estimates that the upstream parapet wall was constructed in the 1930's, possibly in place of an upstream embankment slope. In the late 1940's a concrete headwall was constructed at the inlet to the service spillway and in the early 1950's, the auxiliary spillway drop inlet and conduit was installed.

i. Normal Operating Procedures. According to the Owner's representative, the only operating procedures consist of occasional insertion or removal of flashboards to increase or decrease storage in the pond.

1.3 Pertinent Data

a. Drainage Area. The natural drainage area of Bolivar Pond is 9.9 square miles. However, a separate watershed (11.0 square miles) to the southwest drains into the Bolivar Pond watershed by means of a diversion channel through the basin divide. Therefore, the total area draining to Bolivar Pond encompasses approximately 20.9 square miles to the south, mostly in the Towns of Sharon and Stoughton. The northern portion of the drainage area is industrially, commercially and residentially developed. The southern portion of the drainage basin is heavily forested with swampy regions surrounding Massapoag Lake. Several impoundments are upstream within the drainage basin with Massapoag Lake being the largest with a surface area of 370 acres.

b. Discharge at Damsite. (Refer to discharge calculations in Appendix D.)

1. Outlet Works. According to the Owner's representative, there are no known outlets which could be used to draw down the impoundment.

2. Maximum Known Flood. Although no flood data has been compiled on a continual basis, the Town has kept a record of recent flood events. The most recent flood event occurred on January 27, 1978 when the pond overflowed its northeastern shoreline and nearly washed out Bolivar Street. Refer to Appendix B for further information concerning this event.

3. Ungated Spillway Capacity at Top of Dam. The ungated spillway capacity at top of dam, Elev. 106.5 is 115 cfs.

4. Ungated Spillway Capacity at Test Flood Elevation. At test flood Elev. 109.4, the spillway capacity is about 320 cfs.

5. Gated Spillway Capacity at Normal Pool Elevation. Not Applicable.

6. Gated Spillway Capacity at Test Flood Elevation. Not Applicable.

7. Total Spillway Capacity at Test Flood Elevation. At test flood Elev. 109.4, the spillway capacity is about 320 cfs.

8. Total Project Discharge at Top of Dam. The ungated spillway capacity at top of dam, Elev. 106.5 is 115 cfs.

9. Total Project Discharge at Test Flood Elevation. At test flood Elev. 109.4, the total project discharge is estimated to be 9,405 cfs.

c. Elevation. (NGVD)

1. Streambed at Toe of Dam	94±
2. Bottom of Cutoff	Unknown
3. Maximum Tailwater (Aug. 1955)	101+
4. Recreation Pool	104.5
5. Full Flood Control Pool	NA
6. Spillway Crest (gated)	NA
7. Design Surcharge (Original Design)	Unknown
8. Top of Dam	106.5
9. Test Flood Design Surcharge	109.4

d. Reservoir Length. (Feet)

1. Normal Pool	2,900
2. Flood Control Pool	NA
3. Spillway Crest Pool	2,900
4. Top of Dam	4,000
5. Test Flood Pool	5,000

e. Storage. (Acre-feet)

1. Normal Pool	151
2. Flood Control Pool	NA
3. Spillway Crest Pool	151
4. Top of Dam	200
5. Test Flood Pool	419

f. Reservoir Surface. (Acres)

1. Normal Pool	23
2. Flood Control Pool	NA
3. Spillway Crest Pool	23
4. Top of Dam	38
5. Test Flood Pool	120

g. Dam.

1. Type	Earth Embankment
2. Length	150 feet
3. Height	12 feet
4. Top Width	40 feet
5. Side Slopes	Vertical stone walls
6. Zoning	Unknown
7. Impervious Core	Unknown
8. Cutoff	Unknown
9. Grout Curtain	Unknown

h. Diversion and Regulating Tunnel. None

i. Spillways.

1. Service Spillway	
a) Type	Overflow drop spillway
b) Length of Weir	(2) 46-inch openings
c) Crest Elevation	104.5
d) Gates	Flashboards
e) Upstream Channel	NA
f) Downstream Channel	About 10 feet wide, 200 feet long, flows into Forge Pond.
2. Auxiliary Spillway	
a) Type	Drop inlet closed conduit
b) Length of Weir	16 feet
c) Crest Elevation	104.9
d) Gates	NA
e) Upstream Channel	NA
f) Downstream Channel	270-foot long, 30-inch diameter conduit, outlets into 7-foot wide 200-foot long channel which discharges into Forge Pond.

j Regulating Outlets. None

SECTION 2

ENGINEERING DATA

2.1 Design

No design information with respect to the construction of the dam is available according to Mr. Daniel Therriault of the Town of Canton, Engineering Division.

2.2 Construction

It is believed that the dam was constructed sometime in the mid-nineteenth century. No construction information is available, according to the Owner's representative, Mr. Therriault. Several modifications to the original construction have been made. These modifications are discussed in Section 1.2-h.

2.3 Operation

According to the Owner's representative, operating procedures consist of installation and removal of flashboards for the purpose of increasing or decreasing storage capabilities.

2.4 Evaluation

a. Availability. The following information was obtained from the Town of Canton:

1. A topographic plan of the subject area, reproduced in part and presented as page B-2 in Appendix B.

2. Plan and details of the auxiliary spillway inlet structure.

3. A newspaper account of the January 27, 1978, flooding at Bolivar Street.

4. Flow observations and design data sheet, dated February 9, 1976.

b. Adequacy. Sufficient information was obtained during the field investigation and through subsequent telephone conversations with the Owner's representative to conduct a Phase I dam evaluation.

c. Validity. The information provided by the Town of Canton appears to be valid.

SECTION 3

VISUAL INSPECTION

3.1 Findings

a. General. Bolivar Pond Dam was inspected on October 24, 1979. At the time of inspection, the pool level was approximately 2 feet below the service spillway wall crest. Underwater areas were not inspected.

Observations and comments made during the field inspection appear on a checklist included as Appendix A of this report.

b. Dam. The condition of the dam is considered to be poor as evidenced by the following observations:

1. The vertical stone masonry parapet wall forming the upstream face of the dam is slightly misaligned and has several cracks. (Refer to Photo No. 23 of Appendix C.)

2. The pavement on Bolivar Street shows signs of longitudinal cracking and there is evidence of patching along the edge of the street next to the sidewalk. (Refer to Photo No. 9 of Appendix C.)

3. Several structural cracks were noted in the downstream masonry wall. This wall, as observed from the inside of the DPW garage, has been periodically repaired, but DPW maintenance personnel have been unable to prevent seepage (about 5 gpm).

4. Three abandoned conduits which extend through the dam have been plugged with concrete. Two of these former mill races outlet downstream of the garage, the third pipe, which is 30 inches in diameter, outlets at the downstream face of the downstream masonry wall of the dam (the upstream wall of the DPW garage). Seepage (about 5 gpm) was observed flowing from this wall during the inspection.

5. The area surrounding the service spillway was seriously eroded during the flooding which occurred on January 27, 1978. Since that time, the Town maintenance crews have backfilled the area, but measures have not yet been taken to reseed and protect the area.

6. Trees (up to 12-inch diameter trunks and 40 feet high) growing at the abutments of the stone parapet wall present a danger to the integrity of the dam in the event of uprooting.

7. Trees (up to 12-inch diameter trunks and 40 feet high) in vicinity of the service spillway present a danger to the integrity of the service spillway in the event of their uprooting.

c. Appurtenant Structures. The only outlet from Bolivar Pond, which is currently in use, is the service spillway. The outlet consists of two 46-inch wide openings in a one-foot thick concrete headwall, slotted to facilitate the use of flashboards. At the time of inspection, there were

flashboards from the invert of the spillway channel to an elevation approximately 2 feet below the top of the spillway training wall. The concrete spillway section appears to be in good condition.

The water flowing over the flashboards discharges into an open channel with training walls and flows northerly about 90 feet to a stone block bridge which supports Bolivar Street. Damage to the training walls, resulting from the January 1978 flooding, has not yet been repaired. As a result, flow is impeded along the spillway outlet channel. A profile and photos of the service spillway outlet channel and training walls are included in Appendix B and Appendix C, respectively.

The drop inlet closed conduit auxiliary spillway approximately 175 feet to the right of the service spillway which has a crest elevation of 104.9 (0.4 feet above the service spillway crest) appears to be in satisfactory condition. Drawings and photos of the auxiliary spillway are included in Appendix B and C, respectively. No outlet system which could be used to drain the impoundment was observed.

d. Reservoir Area. The perimeter of Bolivar Pond is well vegetated with the slopes of the surrounding terrain varying from nearly level to approximately 35 percent. There is no evidence of excessive siltation in the reservoir.

e. Downstream Channel. The discharge channel for the service spillway downstream of the Bolivar Street bridge is relatively clear of obstructions which could significantly restrict flow. The discharge is conveyed in a northerly direction about 100 feet beyond the bridge before outletting into Forge Pond. A photo of the channel downstream of the Bolivar Street bridge is presented in photo No. 7 in Appendix C.

3.2 Evaluation

The condition of Bolivar Pond Dam is considered poor. During the inspection, cracking was observed in the upstream and downstream masonry walls and in the pavement on the crest of the dam. Seepage (5 gpm) was observed discharging through the downstream masonry wall of the dam, which forms a wall on the DPW garage. Continued deterioration of these walls could lead to a structural failure of the dam. The trees in the abutments of the dam present a possible hazard to the structural integrity of the embankment in the event of their uprooting.

The service spillway training walls are in need of repair, because they now partially obstruct discharge in the outlet channel. The trees growing in the vicinity of the service spillway present a possible hazard to the structural integrity of the service spillway in the event of their uprooting.

Several photos illustrating the deficiencies are included in Appendix C.

SECTION 4

OPERATION AND MAINTENANCE PROCEDURES

4.1 Operational Procedures

a. General. According to Mr. Daniel Therriault, of the Town of Canton Engineering Division, there are no operational procedures followed on a routine basis. Occasionally, the flashboard elevation will be adjusted to regulate the pond level.

b. Description of Any Warning System in Effect. According to the Owner's representative, there is no warning system currently in effect.

4.1 Maintenance Procedures

a. General. According to the Owner's representative, no maintenance procedures are performed on a routine basis. The only maintenance performed over the last several years includes backfilling in the area around the service spillway,which was eroded during the flooding of January, 1978, and occasional removal of debris at the inlets of the service and auxiliary spillways.

The Town is currently considering replacement of the service spillway, but recent referendum voting failed to appropriate the money necessary for such an improvement.

b. Operating Facilities. According to the Owner's representative, no known operating facilities which would require periodic maintenance exist on this site.

4.3 Evaluation

The current maintenance program has not provided for adequate maintenance of the dam, abutment areas and the service spillway. A program to improve maintenance of the dam is discussed in Section 7 of this report.

SECTION 5

EVALUATION OF HYDRAULIC/HYDROLOGIC FEATURES

5.1 General

The natural drainage area of Bolivar Pond is 9.9 square miles. However, a separate watershed (11.0 square miles) to the southwest drains into the Bolivar Pond watershed by means of a diversion channel through the basin divide. Therefore, the total drainage area of Bolivar Pond is 20.9 square miles. The combined watershed is about 4.0 miles long and 5.4 miles wide, includes the developed portions of the Towns of Stoughton and Sharon and further to the south the forested and swampy areas surrounding Massapoag Lake. The topography ranges from Elev. 540 to Elev. 104.5 which is normal pool at the damsite. Several impoundments are upstream within the drainage basin with Massapoag Lake being the largest with a 370 acre surface.

5.2 Design Data

Neither hydraulic nor hydrologic design data are available for Bolivar Pond Dam.

5.3 Experience Data

Although no flood data has been compiled on a continual basis, the Town has kept a record of recent flood events. The most recent flood event occurred on January 27, 1978 when the pond overflowed its northeastern shoreline and nearly washed out Bolivar Street (see page B-6).

5.4 Test Flood Analysis

The recommended test flood range for a "Small" size, "High" hazard dam is from one-half of the Probable Maximum Flood (PMF) to the full PMF. Based on the extreme hazard to the Town of Canton DPW garage immediately downstream of the dam, the selected test flood for this structure is the full PMF.

Hydrologic and hydraulic calculations were performed with the assistance of the HEC-1-DB computer program. The flood hydrographs were constructed from the Snyder unit hydrographs using Snyder coefficients which reflect the rather flat, swampy nature of the watershed, an initial infiltration of zero and a constant loss rate of 0.05 inches per hour. The Hop Brook Adjustment Factor was used to reduce the Probable Maximum Precipitation based on the drainage area. Stage vs. Discharge and Stage vs. Storage relationships were developed for Bolivar Pond Dam. These relationships were utilized by the program to route the test flood through the dam. The reservoir water surface was assumed to be at the spillway crest elevation at the beginning of the storm event.

The peak inflow and outflow rates for the test flood at Bolivar Pond Dam were calculated as 9,410 cfs and 9,405 cfs, respectively. The peak outflow corresponds to a reservoir stage of 4.9 feet above the spillway crest, or 2.9 feet above the top of dam elevation. The spillway system is able to pass 115 cfs or about 1 percent of the routed test flood outflow without overtopping the dam.

5.5 Dam Failure Analysis

Routing to the primary damage center, the Town of Canton garage, was not considered necessary since any failure of the dam would cause immediate destruction of the property and probable loss of life at this location.

A failure of the embankment was simulated by the HEC-1-DB computer program assuming an 80-foot wide and 12-foot high breach with vertical side slopes developing within 2 hours. The failure is assumed to occur with the reservoir surface at the top of the dam elevation. The resulting outflow was routed to the secondary damage center which consists of residences, commercial and industrial buildings on the shores of Forge Pond approximately 1,500 feet downstream of the dam. The increase in the pond surface was computed to be 3.6 feet and the peak breach outflow was 1,495 cfs. However, all the inhabitable structures in the vicinity were estimated to be at least 4 feet above the normal pool elevation; therefore, little or no damage would occur to these properties.

SECTION 6

EVALUATION OF STRUCTURAL STABILITY

6.1 Visual Observations

Several indications of apparent structural cracking were observed on both the upstream parapet wall and the downstream wall. The most noteable crack was observed near the mid-point of the dam in the downstream wall where a gap has developed which is about an inch wide at the top of the wall and phases out approximately 2 feet above the Town of Canton DPW garage floor. This wall, as observed from inside the DPW garage has been periodically repaired, but DPW maintenance personnel have been unable to prevent seepage (5 gpm) through the wall. Continued deterioration of these walls could lead to a structural failure of the dam.

The trees growing in the abutments of the dam and in the vicinity of the service spillway present a possible hazard to the structural integrity of the dam and service spillway, respectively, in the event of their uprooting.

6.2 Design and Construction Data

There is no known design and construction data available for the original dam. Limited drawings for the auxiliary spillway built in the early 1950's are available.

6.3 Post Construction Changes

Since the original construction it appears that the following 3 major modifications have been made:

a. The upstream parapet wall was constructed in the 1930's, possibly in place of an upstream embankment slope.

b. In the late 1940's a concrete headwall was constructed at the inlet to the service spillway.

c. The auxiliary spillway drop inlet and conduit was installed in the early 1950's.

6.4 Seismic Stability

Bolivar Pond Dam is located in Seismic Zone 3 on the "Seismic Zone Map of Contiguous States". Therefore, according to the Recommended Guidelines for Safety Inspection of Dams, a seismic stability analysis should be performed as recommended in Section 7.

SECTION 7

ASSESSMENT, RECOMMENDATIONS & REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition. Based upon visual inspection of the site on October 24, 1979, the dam appears to be in poor condition.

Several indications of apparent structural cracking were observed on both the upstream parapet wall and the downstream wall. The most notable crack was observed near the mid-point of the dam in the downstream wall where a gap has developed which is about an inch wide at the top of the wall and phases out approximately 2 feet above the Town of Canton DPW garage floor. This wall, as observed from inside the DPW garage, has been periodically repaired, but DPW maintenance personnel have been unable to prevent seepage (5 gpm) through the wall. Continued deterioration of these walls could lead to a structural failure of the dam.

The service spillway appears to be in satisfactory condition, however, the outlet channel training walls were damaged during the flooding of January 1978. As a result, flow is impeded along the outlet channel.

The auxiliary spillway drop inlet closed conduit system appears to be in satisfactory condition.

The trees growing in the abutments of the dam and in the vicinity of the service spillway present a possible hazard to the structural integrity of the dam and service spillway, respectively, in the event of their uprooting.

b. Adequacy of Information. The information made available by personnel of the Town of Canton combined with the information obtained during the field investigation is considered adequate for a Phase I evaluation.

c. Urgency. The recommendations and remedial measures described in this Section should be implemented within one year of receipt of this Phase I Inspection Report.

7.2 Recommendations

Within one year after receipt of this Phase I Inspection Report, the Owner, the Town of Canton, should retain the services of a qualified registered professional engineer to perform the following services:

1. Assess further the potential for overtopping of the dam and the adequacy of the spillway.

2. Study the structural integrity of the dam.

3. Study the cause of seepage through the dam.

4. Investigate the seismic stability of the dam utilizing conventional equivalent static load methods.

5. Direct the removal of the trees adjacent to the service spillway.

6. Design a low-level outlet for emergency drawdown of the reservoir.

7.3 Remedial Measures

a. Operation and Maintenance Procedures. The Owner should also implement the following operation and maintenance measures:

1. Material impeding flow in the service spillway outlet channel should be removed and the training walls should be repaired.

2. Trees adjacent to the upstream masonry parapet wall of the dam should be removed. Voids left by the removal of trees should be filled with suitable, thoroughly compacted material.

3. Suitable vegetation should be established in the area surrounding the service spillway.

4. All spalled or deteriorated concrete should be repaired.

5. A formal surveillance and flood warning plan, including round-the-clock monitoring during heavy precipitation, should be developed.

6. A program of annual technical inspection should be instituted.

7. A comprehensive maintenance program should be developed and adhered to.

7.4 Alternatives

No valid alternatives to the recommendations described above are considered feasible for this dam.

APPENDIX A

INSPECTION CHECKLIST

VISUAL INSPECTION CHECK LIST

INSPECTION TEAM ORGANIZATION

Project: Bolivar Pond Dam

National I.D. #: MA 00807

Location: Canton, MA

Type of Dam: Earth Embankment

Inspection Date(s): October 24, 1979

Weather: Overcast, mid-60's

Pool Elevation: 104.5 MSL

Inspection Team

Leonard Beck	O'Brien & Gere	Structures
Steven Snider	O'Brien & Gere	Foundations & Materials
Alan Hanscom	O'Brien & Gere	Structures
Rodney Georges	Bryant & Associates	Hydrology/Hydraulics

*Mr. John J. Williams, Vice-President, O'Brien & Gere has visited the site but not necessarily in conjunction with the inspection team.

Owner's Representative

Mr. Stephen D. Anderson & Mr. Daniel J. Therriault of the Engineering Division of the Town of Canton

VISUAL INSPECTION CHECK LIST

Project: Bolivar Pond Dam

National I.D. #: MA 00807

Date(s): October 24, 1979

AREA EVALUATED	CONDITIONS
DAM EMBANKMENT (At Service Spillway)	
Crest Elevation (Top of Spillway Wall)	106.0'±
Current Pool Elevation	104.5' (Assumed)
Maximum Impoundment to Date	Unknown
Surface Cracks (Refer to Photo #9 of Appendix C.)	Along Bolivar St.
Pavement Condition	Surface Cracking
Movement or Settlement of Crest	Slight
Lateral Movement	Embankment recently filled
Vertical Alignment	Embankment recently filled
Horizontal Alignment	Embankment recently filled
Condition at Abutment and at Concrete Structures	Severe Erosion from 1/27/78 flooding
Indications of Movements of Structural Items on Slopes	Training walls at service spillway have shifted
Trespassing on Slopes	Indications not observed
Vegetation on Slopes	On either side of spillway-heavy growth
Sloughing or Erosion of Slopes or Abutments	At spillway training walls & around headwall
Rock Slope Protection - Riprap Failures	N/A

VISUAL INSPECTION CHECK LIST

Project: Bolivar Pond Dam

National I.D. #: MA 00807

Date(s): October 24, 1979

AREA EVALUATED	CONDITIONS
DAM EMBANKMENT (Con't)	
Unusual Movement or Cracking at or near Toes	Cracking in d/s retaining wall
Unusual Embankment or Downstream Seepage	Appreciable seepage through retaining wall
Piping or Boils	None Observed
Foundation Drainage Features	N/A
Toe Drains	None except storm drains
Instrumentation System	N/A

VISUAL INSPECTION CHECK LIST

Project: Bolivar Pond Dam

National I.D. #: MA 00807

Date(s): October 24, 1979

AREA EVALUATED	CONDITIONS
CONCRETE/MASONRY DAM	
Crest Elevation	110.5±
Current Pool Elevation (Assumed)	104.5
Maximum Impoundment to Date	Unknown
Any Noticeable Seepage	At d/s retaining wall
Conditions of Abutment	Cracks in masonry & large trees
Drains	None Observed
Water Passages	(3) Abandoned Races
Foundation	Unknown
Masonry/Concrete Surface Cracks	Several-top and face of parapet wall
Structural Cracking	Both u/s & d/s walls
Vertical and Horizontal Alignment	Slight misalignment
Monolith Joints	Much Cracking
Construction Joints	N/A
Upstream Embankment	Large trees at abutments
Instrumentation System	N/A
Inspection Galleries	N/A

VISUAL INSPECTION CHECK LIST

Project: Bolivar Pond Dam

National I.D. #: MA 00807

Date(s): October 24, 1979

AREA EVALUATED	CONDITIONS
OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	
a. Approach Channel (weir to bridge)	Refer to Photo #4 of Appendix C
General Condition	Very poor
Loose Rock Overhanging Channel	Yes
Trees Overhanging Channel	Few Branches
Floor of Approach Channel	Several stones and debris
b. Weir and Training Walls	
General Condition of Concrete	East side training wall has failed
Rust or Staining	None Observed
Spalling	Slight
Any Visible Reinforcing	No
Any Seepage or Efflorescence	None Observed
Drain Holes	None Observed
c. Discharge Channel (d/s of bridge)	
General Condition	Fair-clear of major size debris

VISUAL INSPECTION CHECK LIST

Project: Bolivar Pond Dam

National I.D. #: MA 00807

Date(s): October 24, 1979

AREA EVALUATED	CONDITIONS
OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS (Con't)	
Loose Rock Overhanging Channel	At few locations
Trees Overhanging Channel	Yes
Floor of Channel	Several stones
Other Obstructions	Major obstruction at bridge

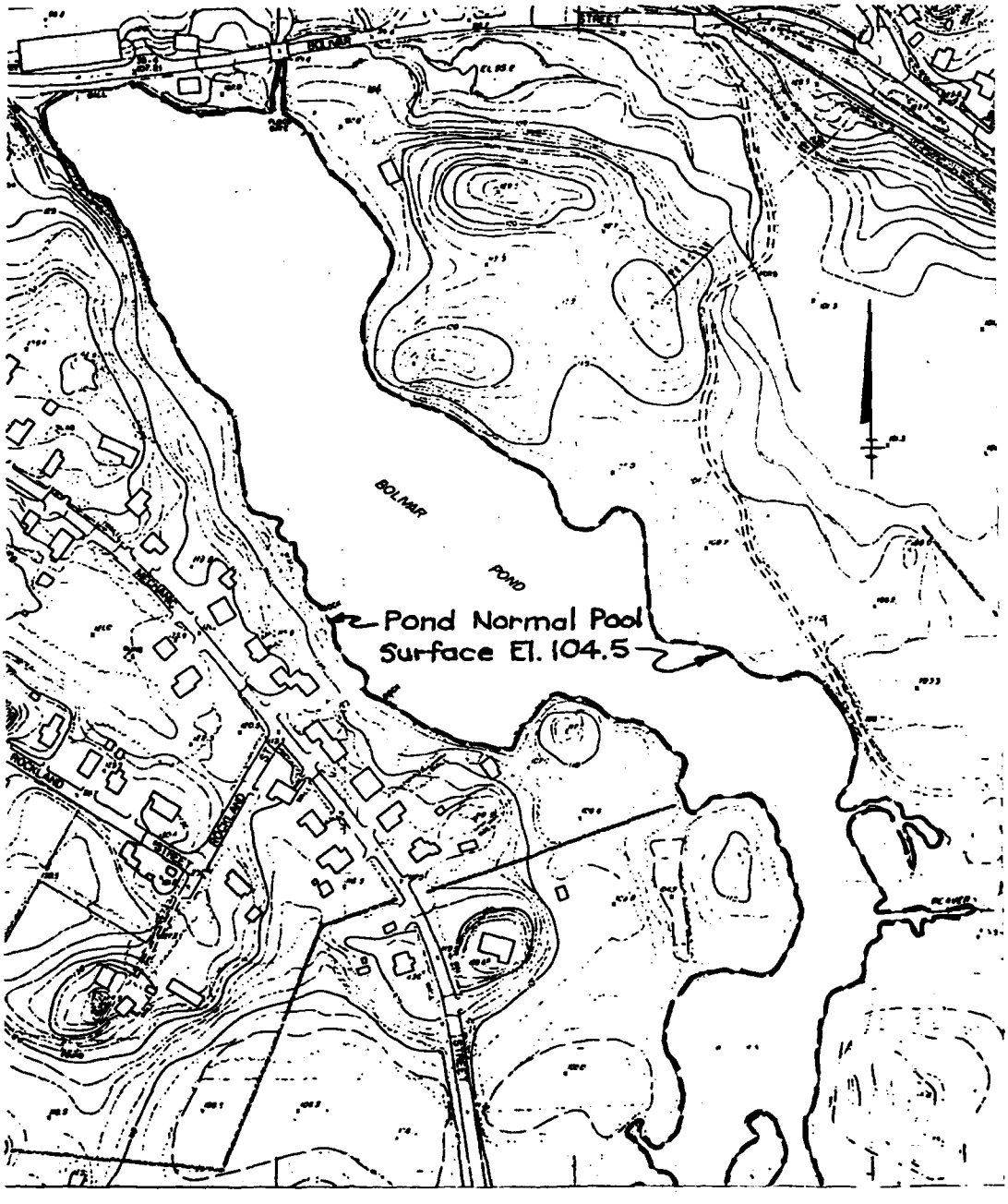
APPENDIX B

ENGINEERING DATA

APPENDIX B

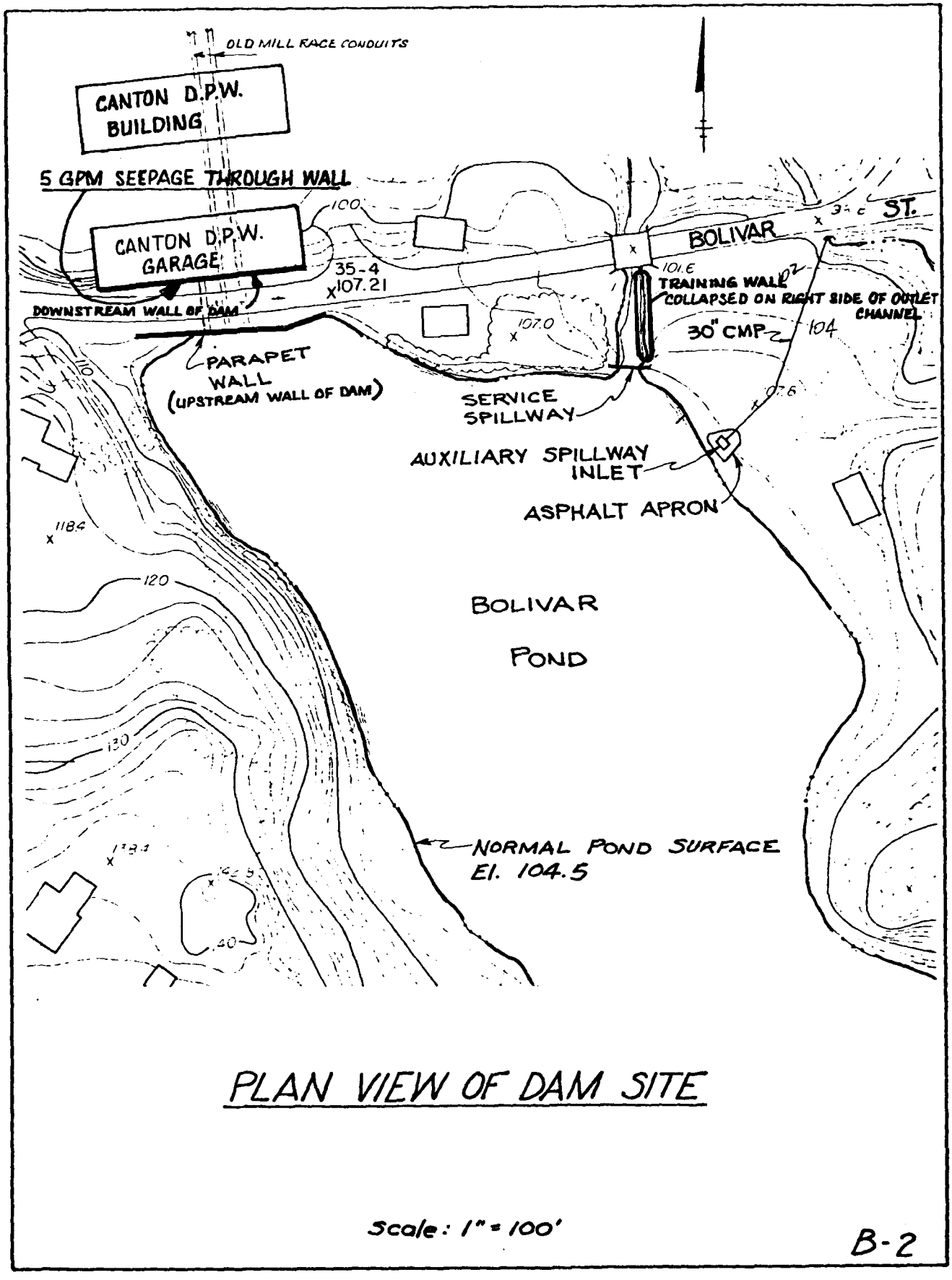
ENGINEERING DATA

TABLE OF CONTENTS



PLAN VIEW OF POND AREA

B-1



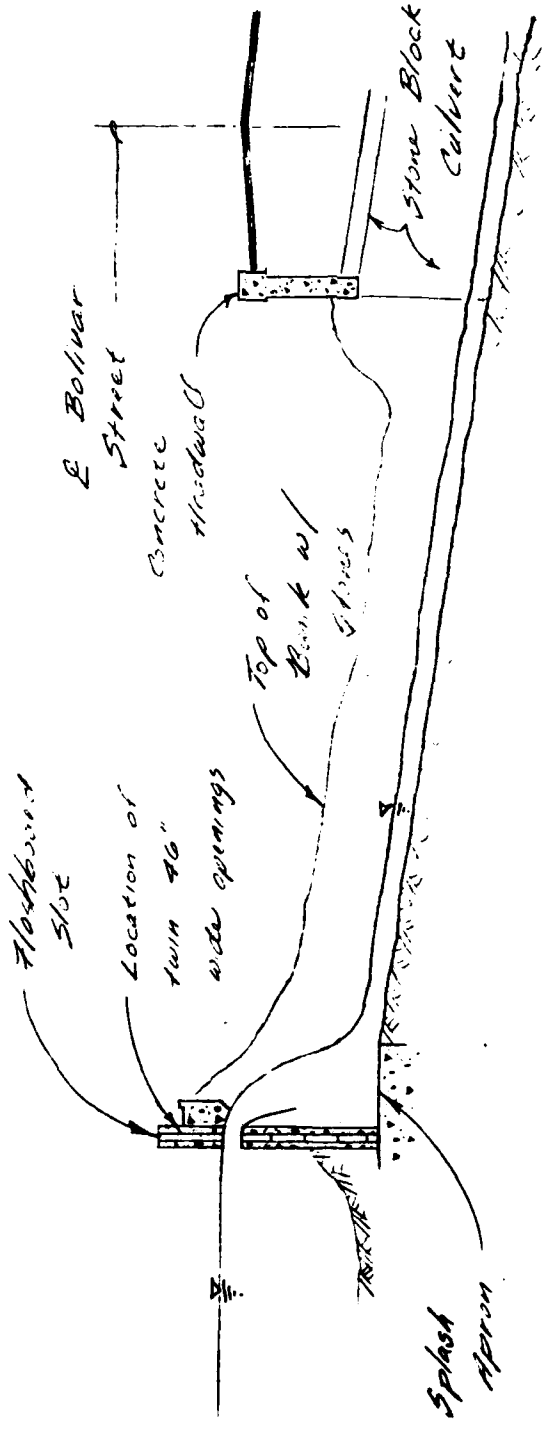
PLAN VIEW OF DAM SITE

Scale: 1" = 100'

B-2

O'BRIEN & GERE
ENGINEERS, INC.

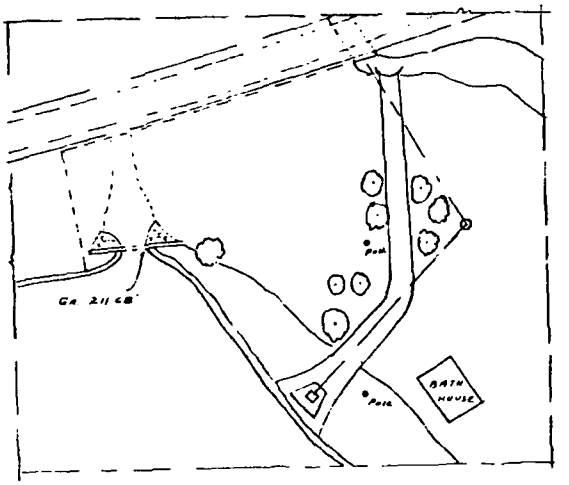
SUBJECT	SHEET	BY	DATE	JOB NO
BOLIVAR POND DAM				



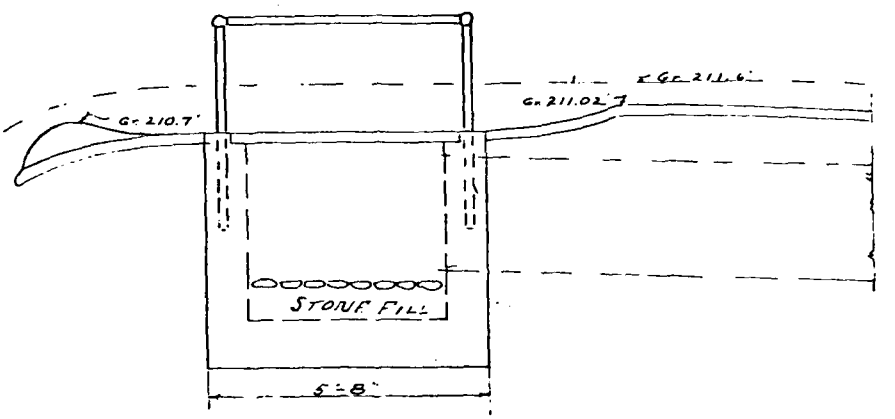
PROFILE : SERVICE SPILLWAY

Not To Scale

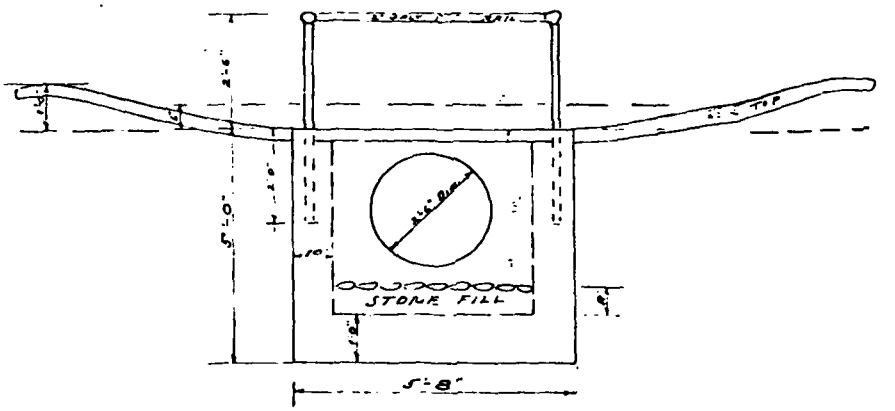
B-3



PLAN VIEW



SIDE VIEW



END VIEW

AUXILIARY SPILLWAY

B-4

2/9/76

RDH

BOLIVAR POND DAM AND SPILLWAY

Observed Flow at Dam at Bolivar Street

2/4/76 Flow = 85± Cubic Feet Per Second (cfs)

2/8/76 Flow = 710± cfs
Major Backwater Flooding

New Design Parameters:

1. Design Storm Frequency = 100 years.
2. Design Discharge Q(flow) by McMath Formula.
3. Design Q to discharge over or through new structure.

Design Flow Calculations:

McMath Formula $Q = AciS^{5}/A$
A= Drainage Area = 6770 Acres
c= Drainage Coefficient = .40
i= 100 year storm intensity (20 minutes) = 5.4
s= Slope of Drainage Area Ft/100Ft. = 8.2
Q = 3771 cfs

FROM THE TOWN OF CANTON ENGINEERING DEPT.

Floods Drench Canton

1-27-78

CANTON — Local officials spent an anxious day and night yesterday, keeping a careful watch over the Shepard's Pond dam and Bolivar Pond headwall.

Canton was particularly hard hit with flooding problems and, besides having to contend with the pond trouble, the fire department had pumped more than 200 basements by late last night.

Water levels had begun to recede by 10:30 p.m. but there were several anxious moments before that finally happened.

Selectmen worried that the town-owned Shepard's Pond dam, alleged to be unsound for some time now, would break under heavy floodwaters from Lake Massapoag in Sharon and that town's waterways.

After an emergency session yesterday morning, selectmen got Sharon officials to have flashboards replaced in Lake Massapoag sluiceways so that the water would be held back. The Canton dam was reported to be holding well last night.

Police said this morning that the situation had appeared to return to normal, and they have recalled the officer they had stationed at the dam during the night. However, Bolivar Street remained closed this morning.

However, precautions taken at Lake Massapoag were too late to help the problem downstream from Shepard's Pond at Bolivar Pond.

Selectman Daniel Flood said water started surging onto Bolivar Street from the pond in the morning "and got quite high because of the large snowbanks on the side of the roadway."

The snow piles were pulled down but water continued to flood over the street and was still about eight inches deep last night at about 10:30.

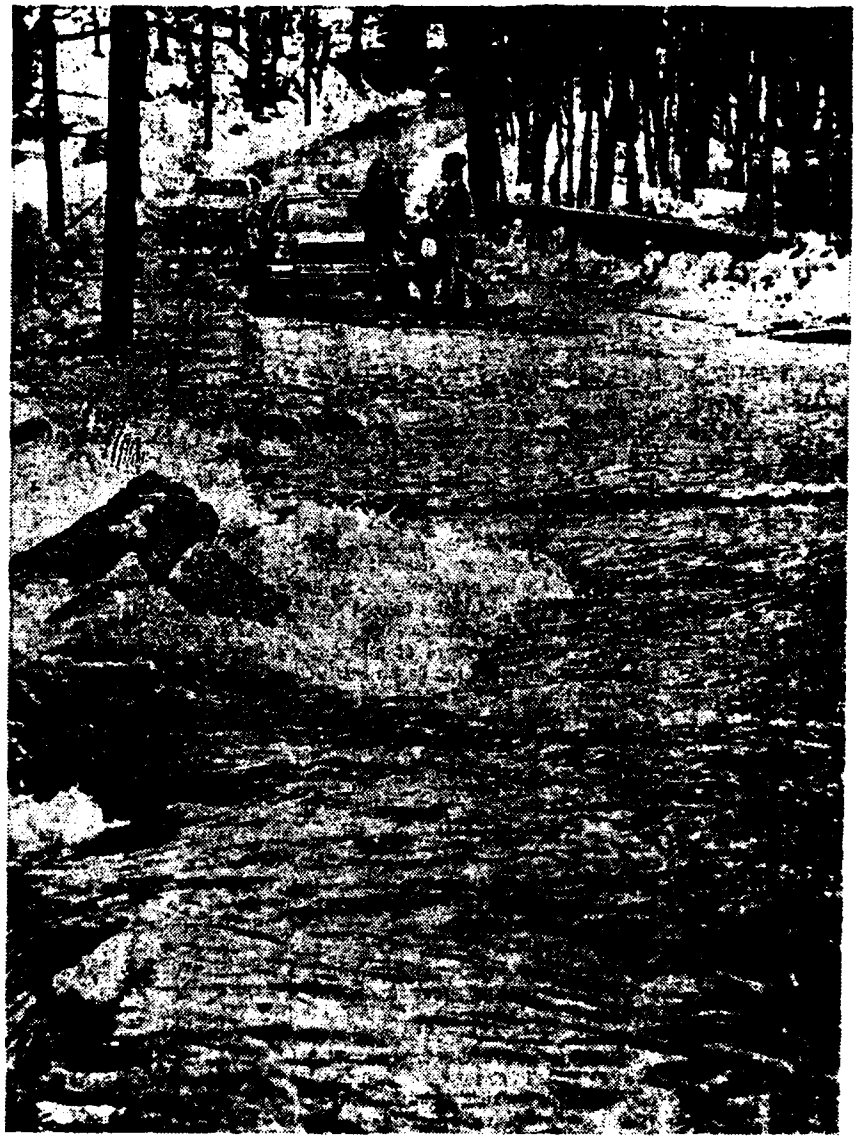
Bolivar Street was closed to traffic yesterday and will not be reopened until the public works department can see how much erosion damage has been done.

Mr. Flood said water was threatening to erode the headwall at Bolivar beach, as well, last night but that the danger had apparently passed.

As a precaution, police details were working overtime last night, standing watch at both Bolivar Pond and Shepard's Pond.

Meanwhile, news from the fire department proved that high water was not restricted to any one part of Canton but was troublesome everywhere — "all 20 square miles."

The fire department had four crews working to pump cellars yesterday and will have the crews out all day today, as well. "Well over 200 basements had been pumped out by 10 last night, according to a department spokesman.



ROAD AWASH — Waters in Canton's Bolivar Pond washed out a sluiceway and flooded Bolivar Street, closing it early yesterday to all traffic. (Photo by Daniel T. Power)

Report on Flood of January 1978

B-6

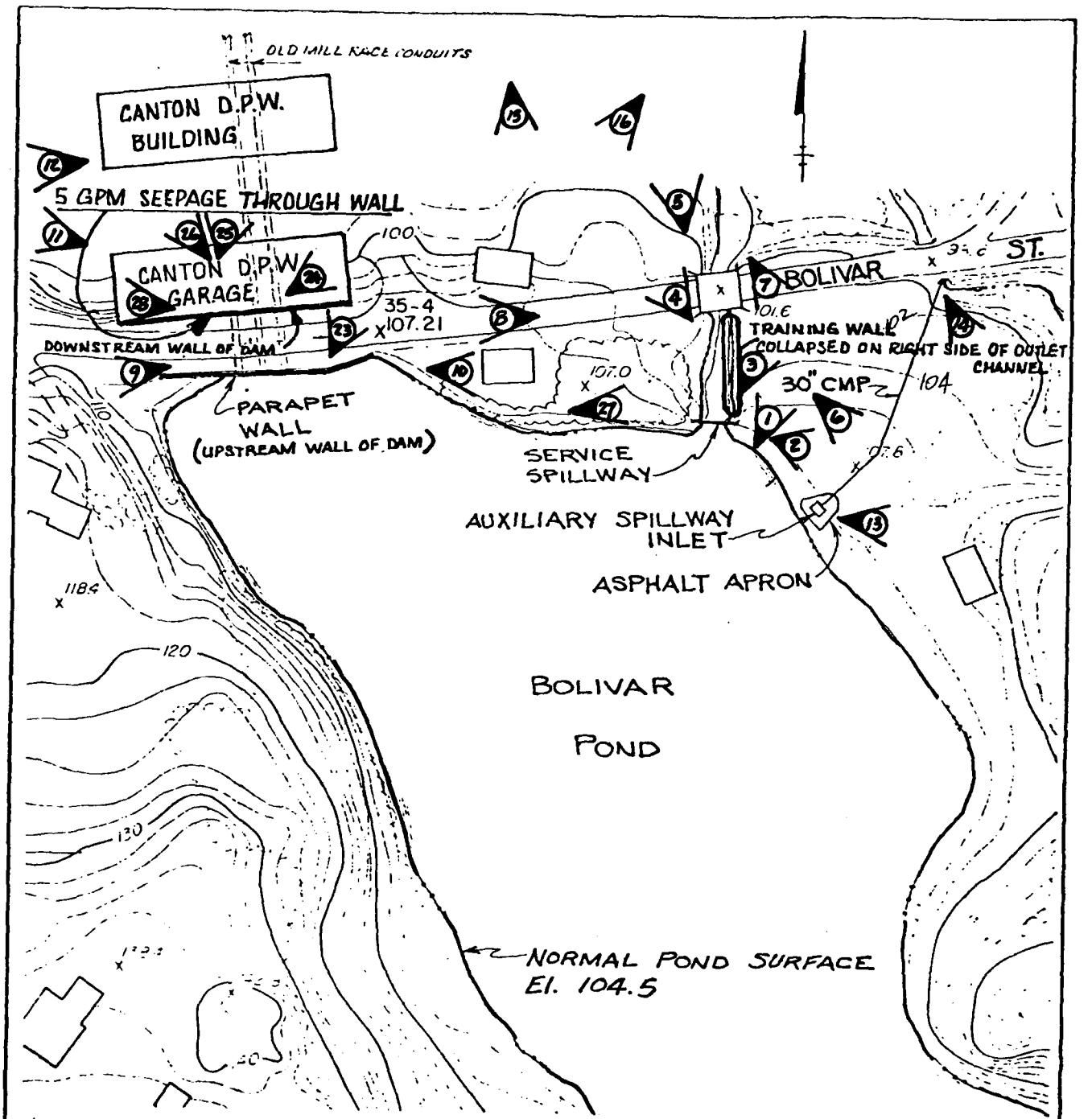
APPENDIX C

PHOTOGRAPHS

APPENDIX C
SELECTED PHOTOGRAPHS OF PROJECT

APPENDIX C (Con't)

SELECTED PHOTOGRAPHS OF PROJECT

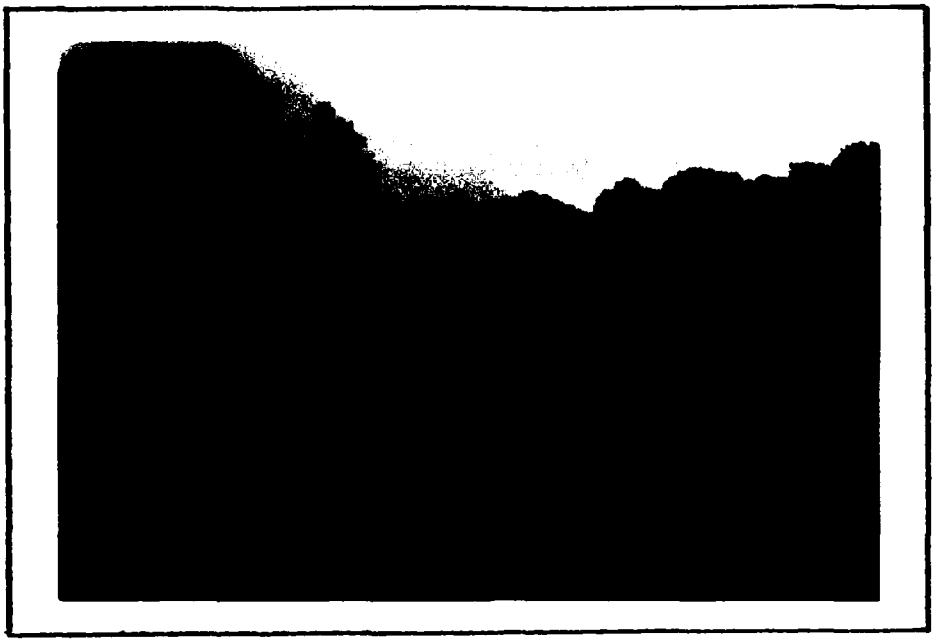


PLAN VIEW OF DAM SITE

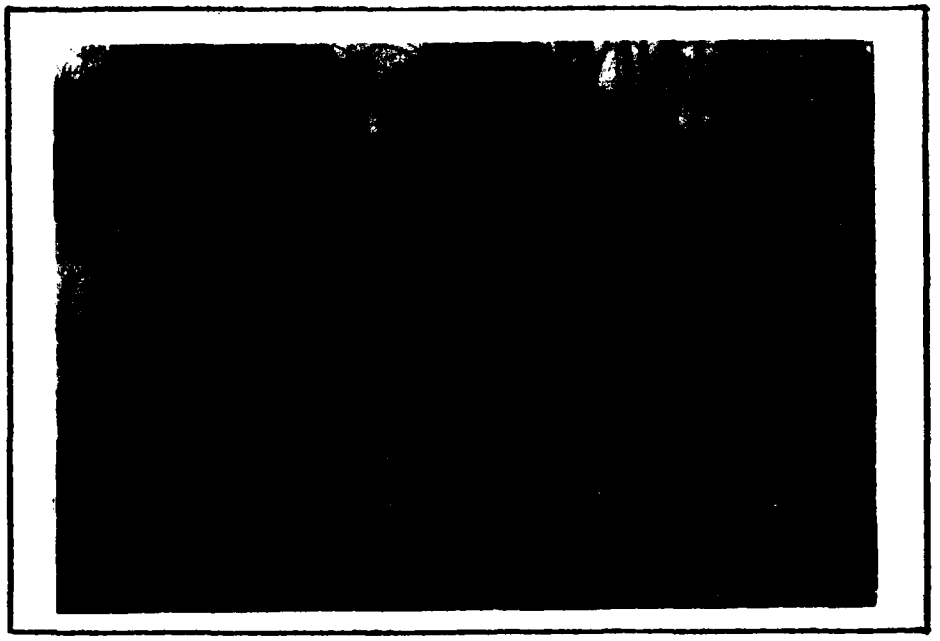
LEGEND ① THE LOCATION AND DIRECTION IN WHICH EACH PHOTO WAS TAKEN AND THE NUMBER OF THE PHOTO

Scale: 1" = 100'

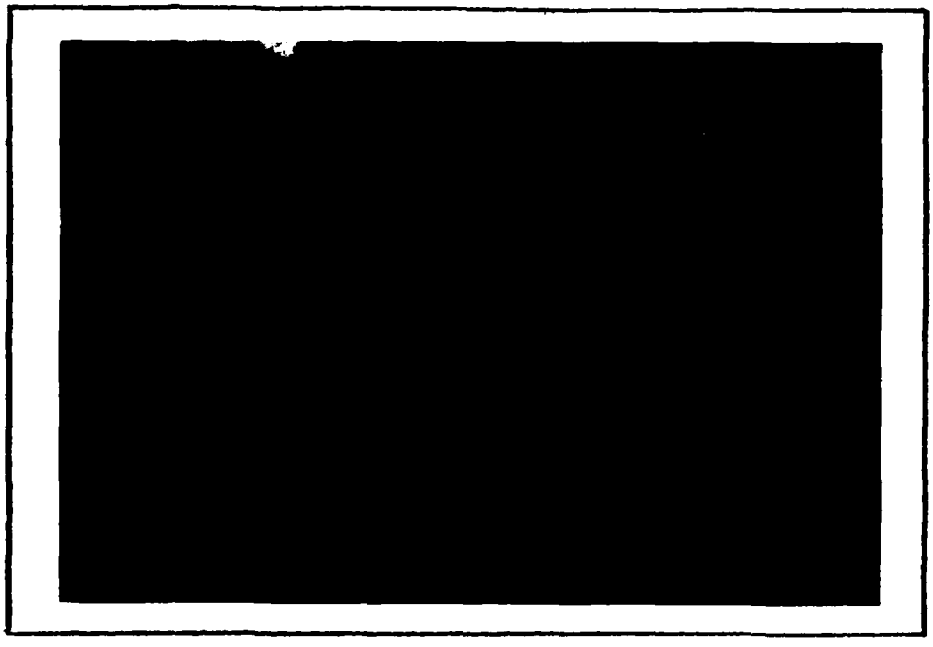
PG. A



1. BOLIVAR POND AS VIEWED FROM THE SPILLWAY (10/24/79)

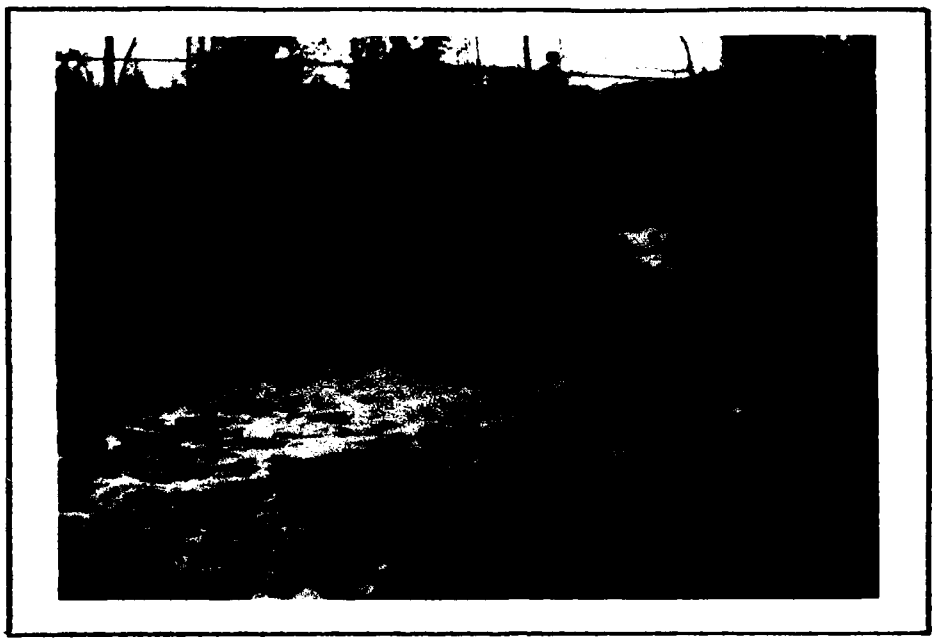


2. REINFORCED CONCRETE SPILLWAY AS SEEN FROM THE RIGHT ABUTMENT. (10/24/79)

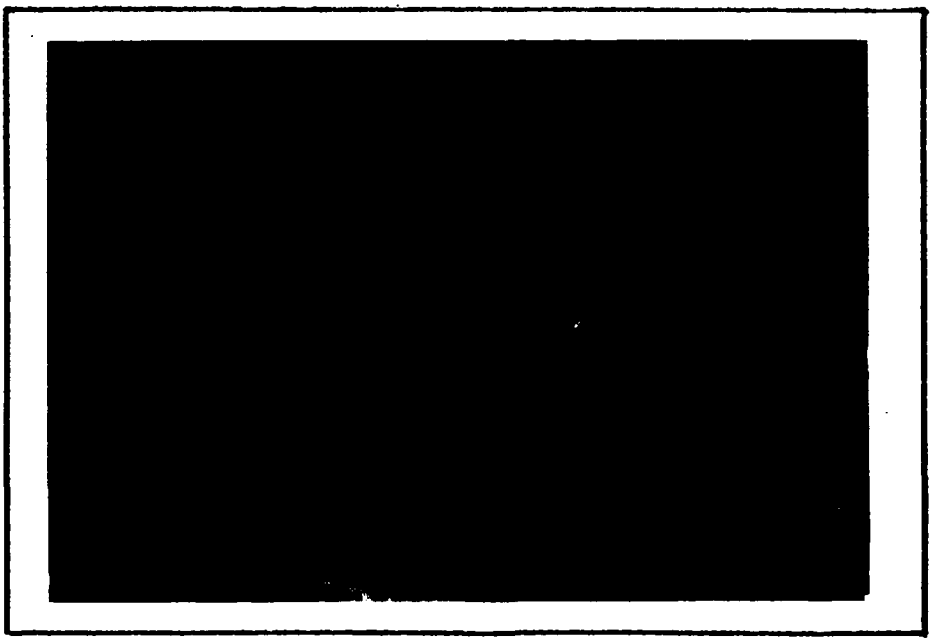


3. SPILLWAY WITH ABOUT TWO THIRDS OF THE STOP LOGS IN PLACE. (10/24/79)

4. SPILLWAY OUTLET CHANNEL AND FAILED MASONRY TRAINING WALL LOOKING UPSTREAM.. (10/24/79)



5. LOOKING UPSTREAM THROUGH THE BOLIVAR STREET BRIDGE ABOUT 100 FEET DOWNSTREAM OF THE SPILLWAY. NOTE THE STONE BRIDGE BEAM. (10/24/79)



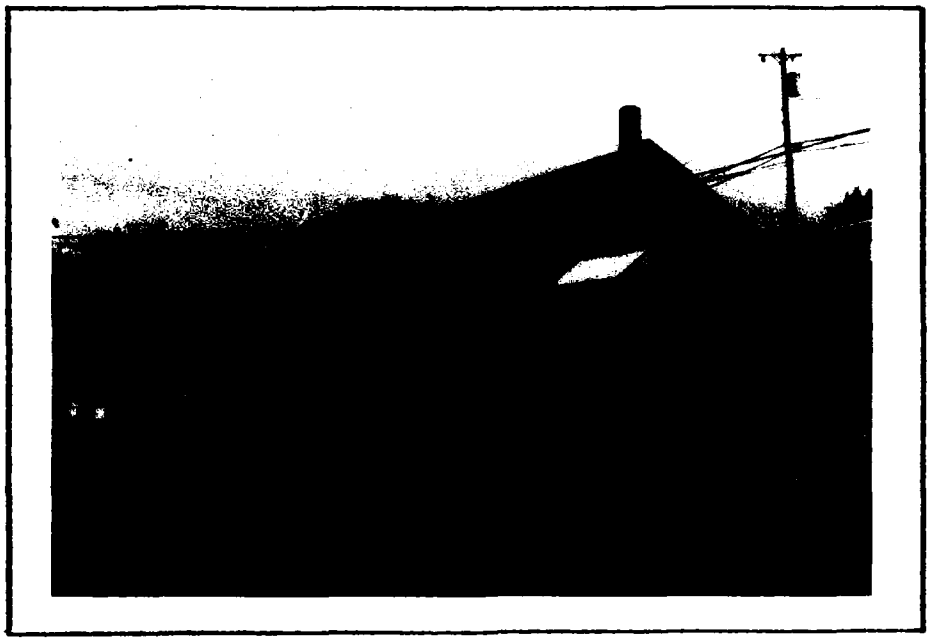
6. SPILLWAY DISCHARGE CHANNEL WITH THE BOLIVAR STREET BRIDGE IN THE BACKGROUND. (10/24/79)

7. SPILLWAY DISCHARGE CHANNEL IMMEDIATELY DOWNSTREAM OF BOLIVAR STREET. (10/24/79)

8. BOLIVAR STREET 100 FEET DOWNSTREAM OF THE SPILLWAY (10/24/79)

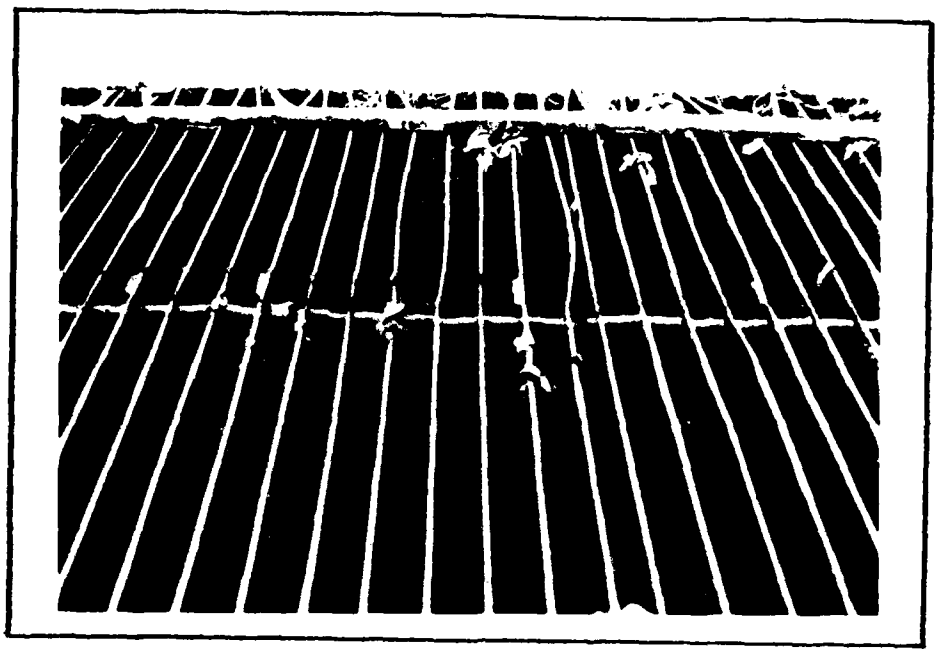
9. BOLIVAR STREET AS VIEWED FROM THE LEFT ABUTMENT.(10/24/79)

10. MASONRY RETAINING WALL WHICH TIES INTO THE LEFT ABUTMENT AND SUPPORTS THE BOLIVAR STREET EMBANKMENT. ROOF OF THE CANTON PUBLIC WORKS GARAGE IS IN THE BACKGROUND. (10/24/79)



11. CANTON PUBLIC WORKS GARAGE WITH BACK WALL THAT SUPPORTS BOLIVAR STREET EMBANKMENT. (10/24/79)

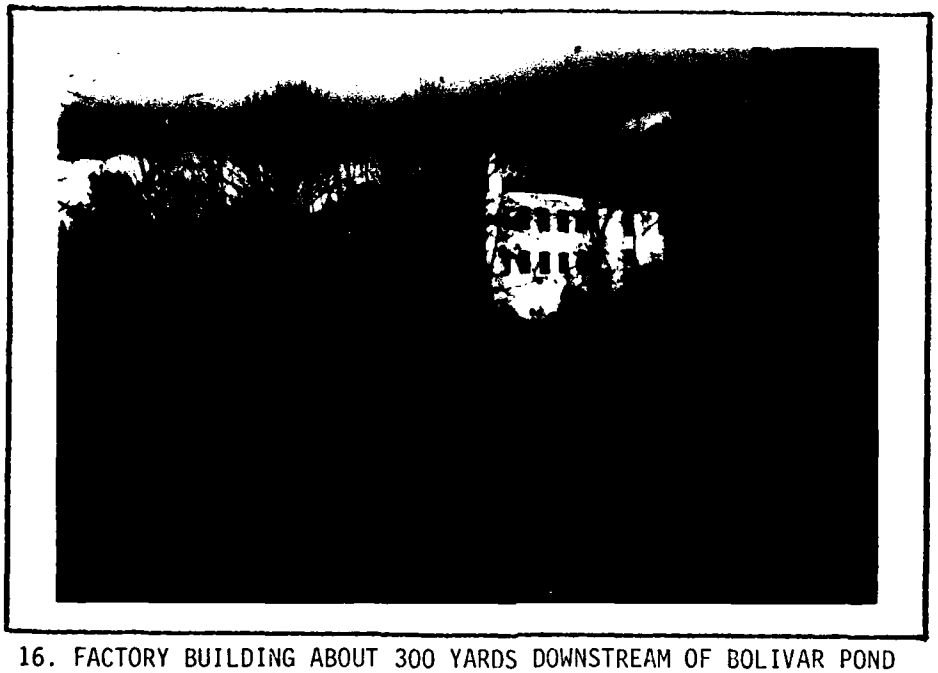
12. CANTON PUBLIC WORKS BUILDING IMMEDIATELY DOWNSTREAM OF THE PUBLIC WORKS GARAGE. (10/24/79)



13. TRASH RACK OVER EMERGENCY DROP-INLET NEAR RIGHT ABUTMENT. (10/24/79)

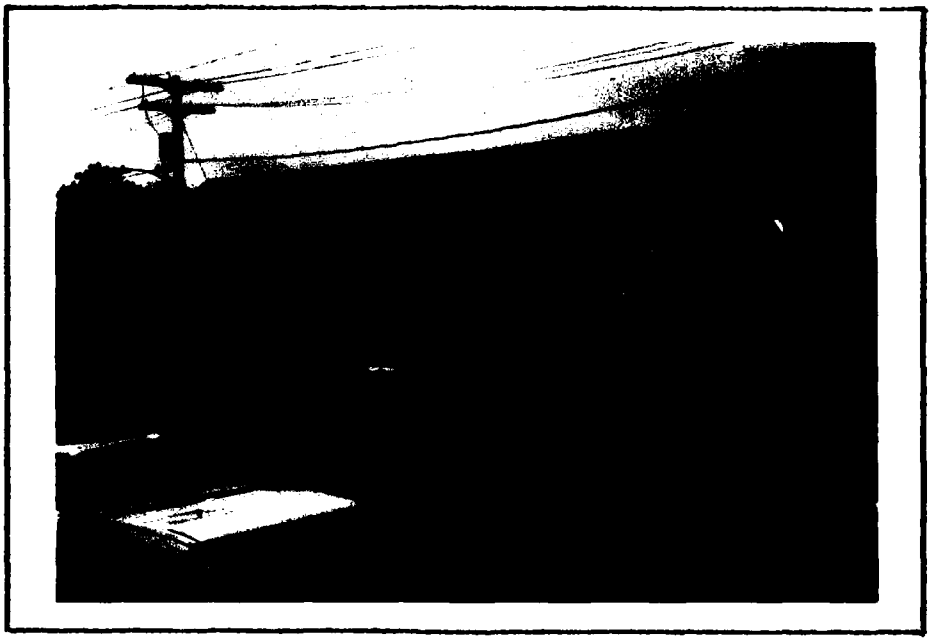
14. OUTLET OF 30 INCH CMP CONNECTED TO EMERGENCY DROP-INLET. (10/24/79)

15. PARTIALLY DRAINED FORGE POND ABOUT 200 FEET DOWNSTREAM OF BOLIVAR POND DAM. (10/24/79)

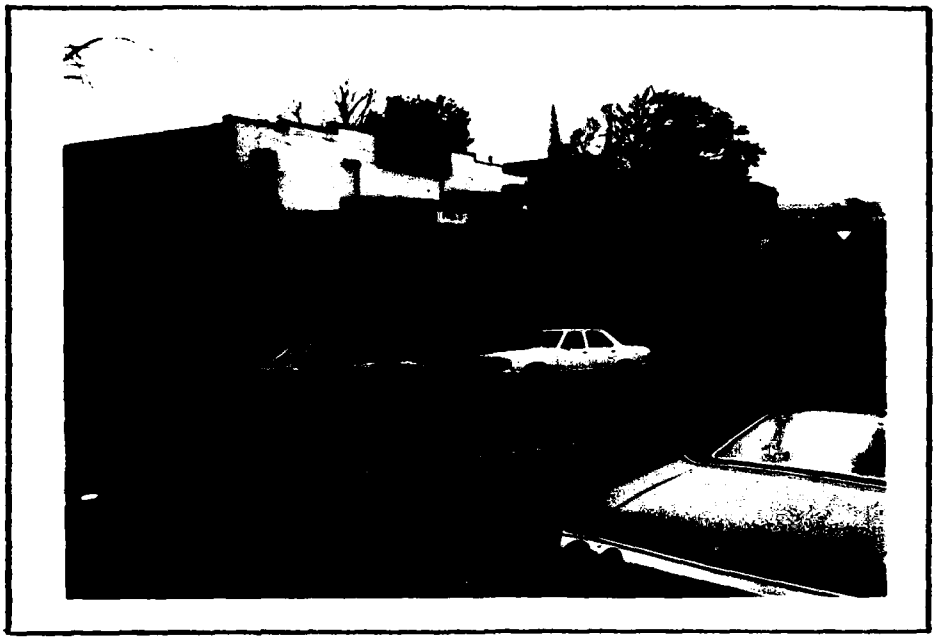


16. FACTORY BUILDING ABOUT 300 YARDS DOWNSTREAM OF BOLIVAR POND DAM. (10/24/79)

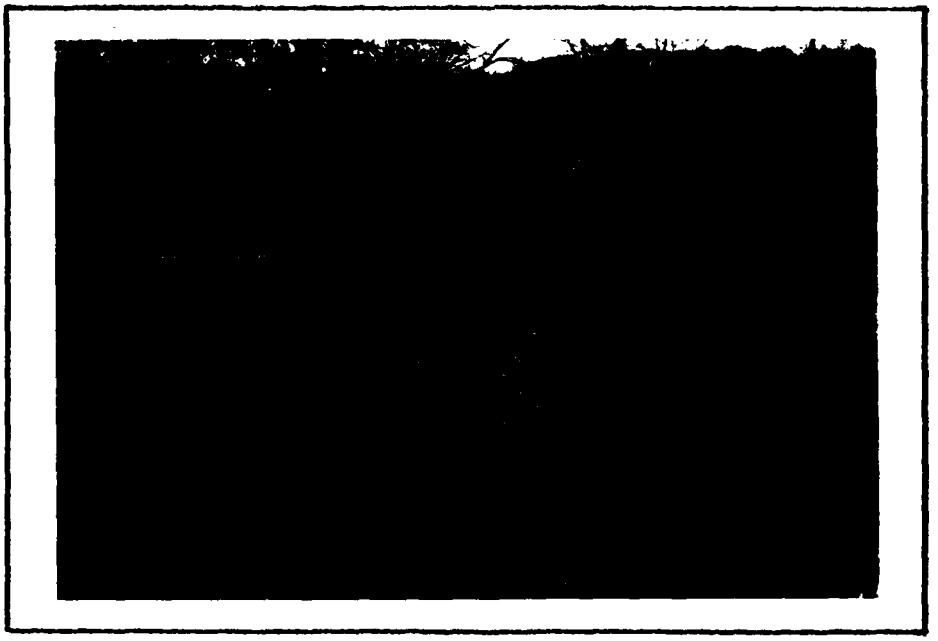
17. FORGE POND SPILLWAY APPROXIMATELY ½ MILE DOWNSTREAM OF BOLIVAR POND DAM. (10/24/79)



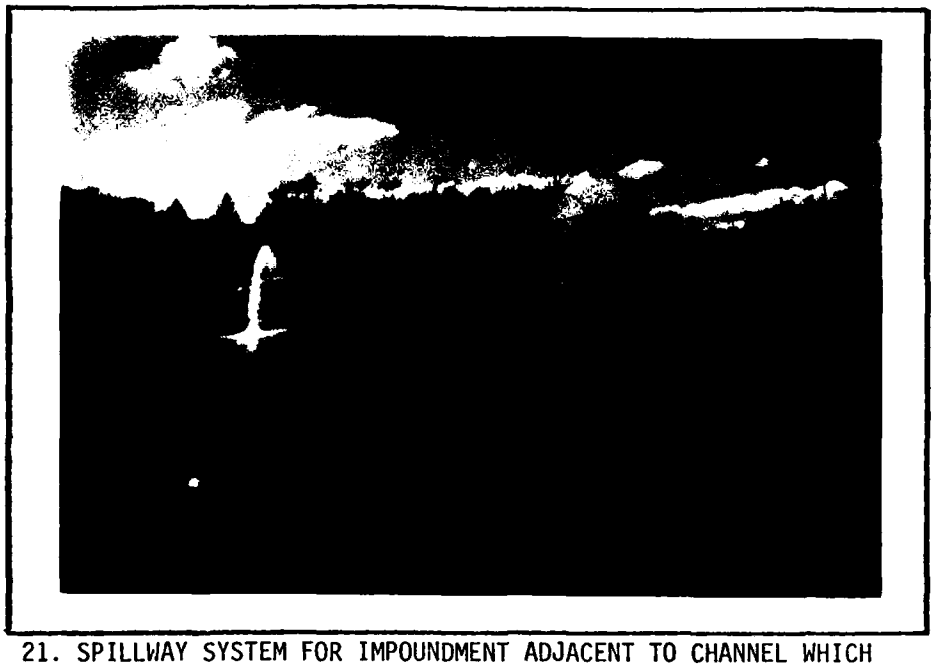
18. POTENTIAL HAZARD AREA ON WASHINGTON STREET APPROXIMATELY ½ MILE DOWNSTREAM OF BOLIVAR POND DAM. (10/24/79)



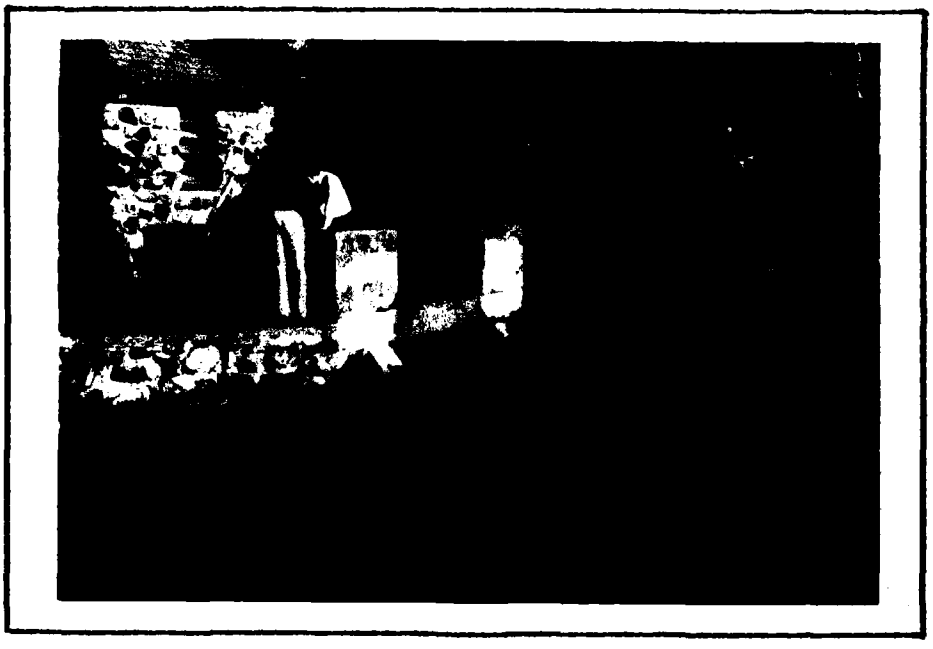
19. POTENTIAL HAZARD AREA ON WASHINGTON STREET APPROXIMATELY ½ MILE DOWNSTREAM OF BOLIVAR POND DAM (ACROSS THE STREET FROM PHOTO 18). (10/24/79)



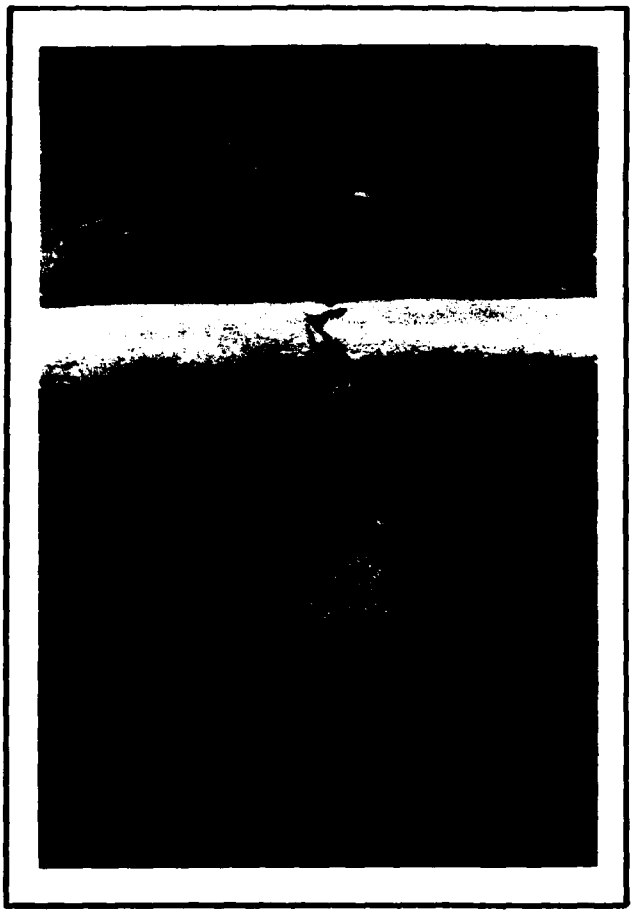
20. CHANNEL WHICH CONNECTS WATERSHED SADDLE ABOUT 2 MILES UPSTREAM OF BOLIVAR POND DAM. THIS CHANNEL ADDS 11 SQ. MILES TO THE BOLIVAR POND WATERSHED. (10/24/79)



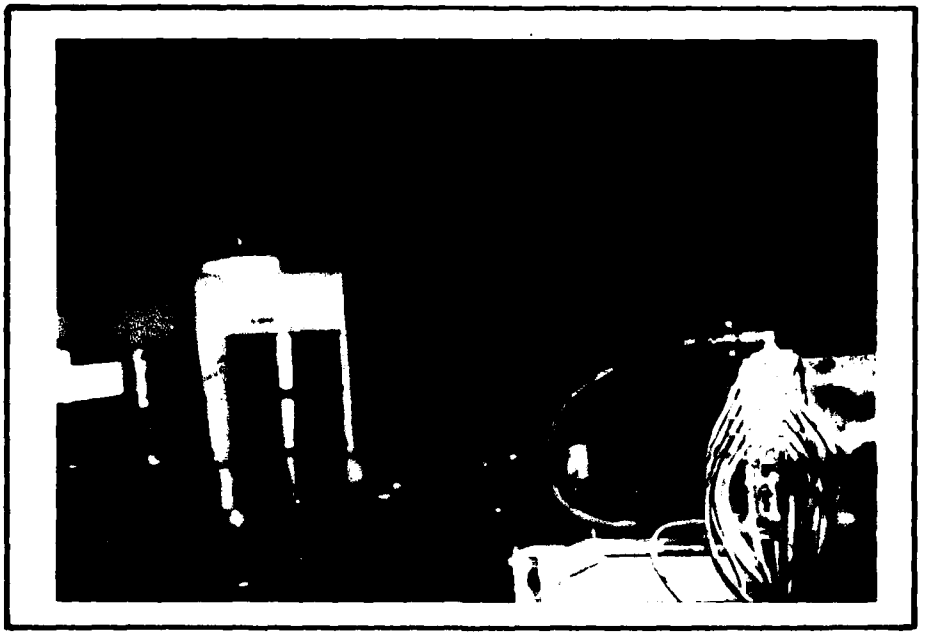
21. SPILLWAY SYSTEM FOR IMPOUNDMENT ADJACENT TO CHANNEL WHICH CONNECTS WATERSHED SADDLE. (10/24/79)



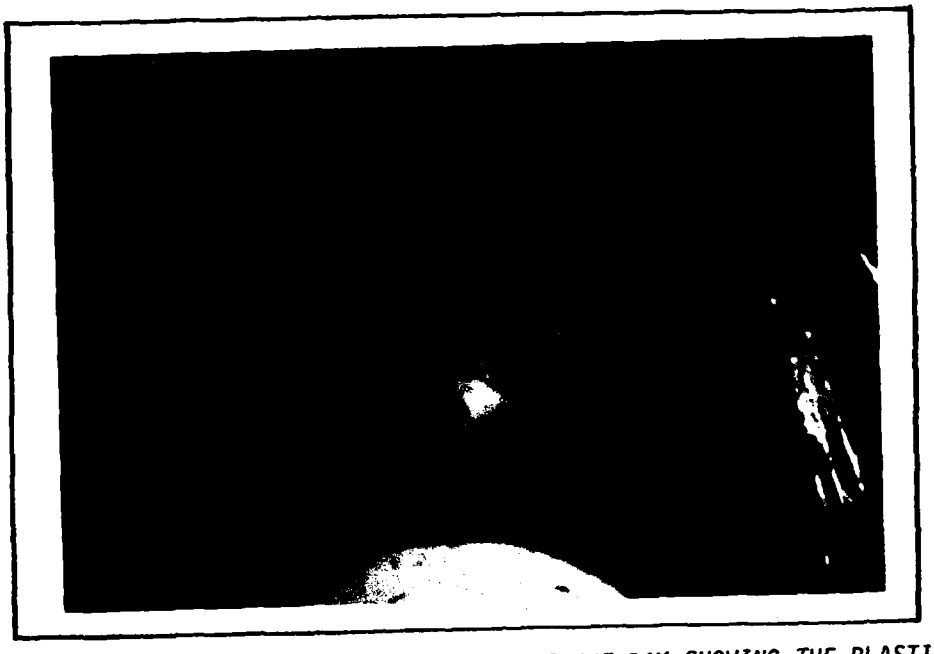
22. MASSAPOAG POND SPILLWAY APPROXIMATELY 5 MILES UPSTREAM OF BOLIVAR POND DAM. (10/24/79)



23. LARGEST CRACK IN THE UPSTREAM TRAINING WALL. (10/24/79)

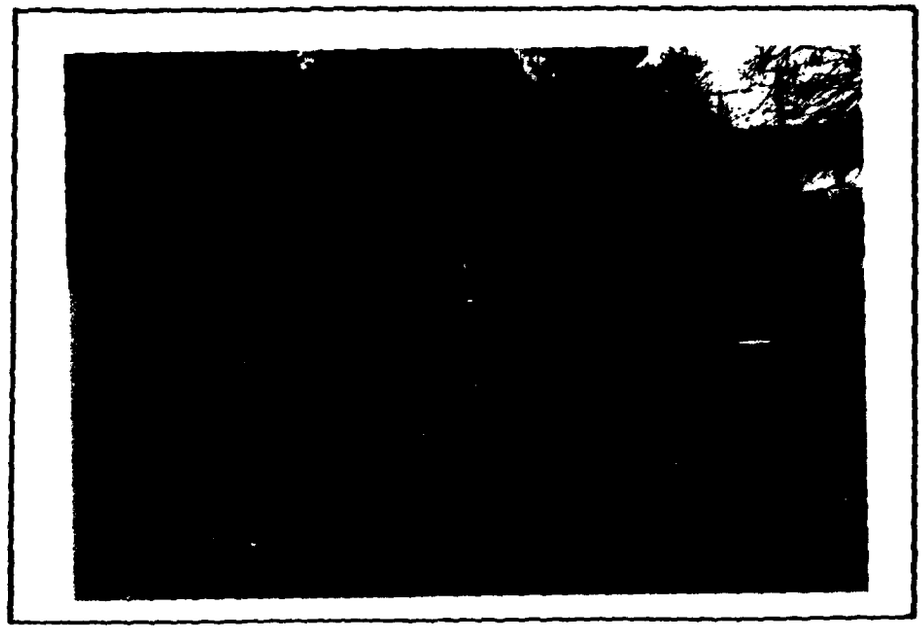


24. INSIDE THE TOWN OF CANTON GARAGE SHOWING THE WALL WHICH IS THE DOWNSTREAM FACE OF THE DAM. NOTE THE PLASTIC SHEET WHICH IS USED TO KEEP SEEPAGE OFF TOWN EQUIPMENT. (10/24/79)

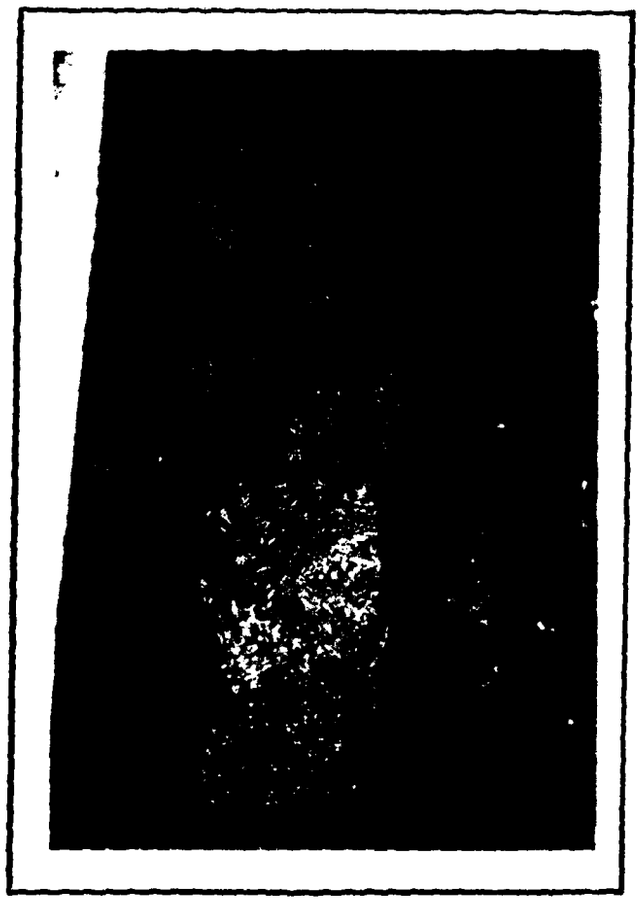


25. CLOSE-UP OF THE DOWNSTREAM FACE OF THE DAM SHOWING THE PLASTIC SHEET USED TO KEEP SEEPAGE OFF TOWN EQUIPMENT. (10/24/79)

26. CAPPED MILL RACE CONDUIT IN THE DOWNSTREAM FACE OF THE DAM. (10/24/79)



27. CONDITIONS AT THE LEFT ABUTMENT OF THE DAM. (10/24/79)



28. COLLECTION POINT FOR SEEPAGE THROUGH THE DOWNSTREAM FACE OF THE DAM. PIPE ON THE LEFT IS USED TO DISCHARGE SEEPAGE UNDER THE GARAGE FLOOR. (10/24/79)

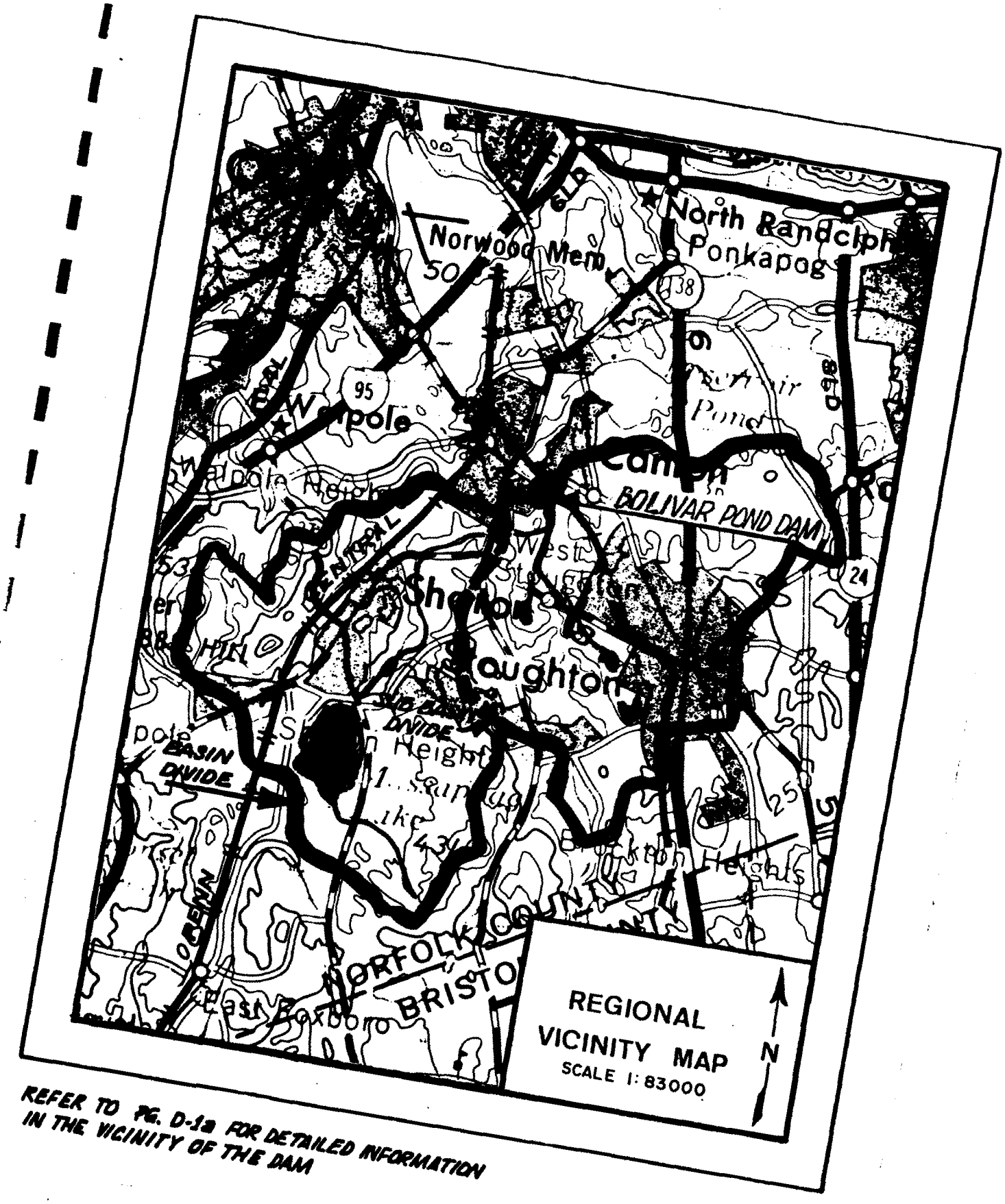
APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

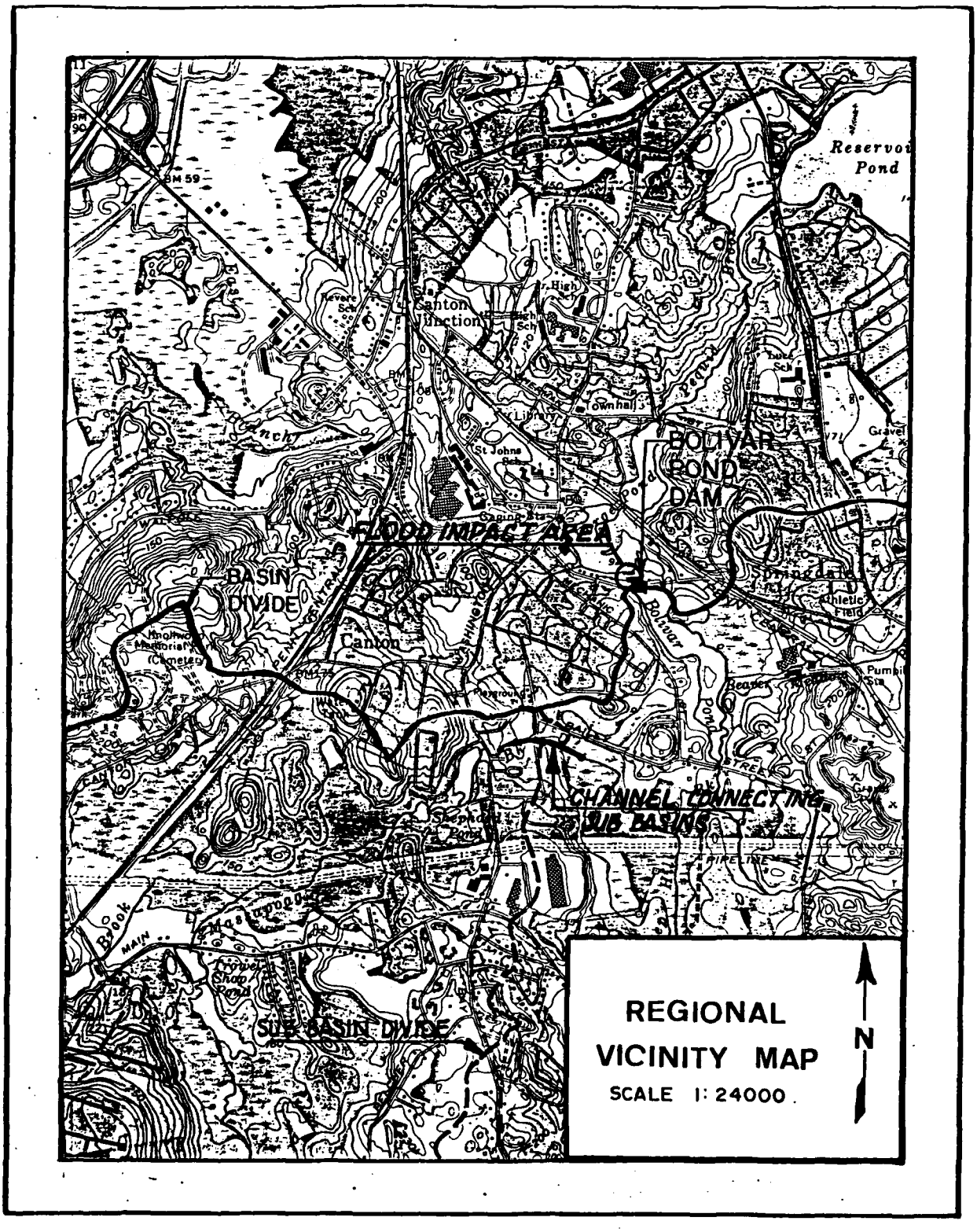
APPENDIX D

HYDROLOGIC & HYDRAULIC COMPUTATIONS

TABLE OF CONTENTS



REFER TO PG. D-1a FOR DETAILED INFORMATION IN THE VICINITY OF THE DAM


Reservoir
Pond
Canton Junction
Town Hall
BOLIVAR POND DAM
FLOOD IMPACT AREA
BASIN DIVIDE
Canton
Athletic Field
CHANNEL CONNECTING SUB BASINS
SUB BASIN DIVIDE
REGIONAL VICINITY MAP
SCALE 1: 24000
N

O'BRIEN & GERE ENGINEERS, INC.

SUBJECT	SHEET	BY	DATE	JOB NO
BOLIVAR POND DAM - H & H	D-2	RRB		

HYDROLOGY CALCS.

TOTAL DRAINAGE AREA (INCLUDING SUB-BASIN TO SOUTHWEST WHICH DRAINS INTO THE BOLIVAR POND WATERSHED BY MEANS OF A CHANNEL THROUGH THE BASIN DIVIDE) = 20.9 SQUARE MILES

PMP DATA

FROM HMS # 33, THE 24 HR., 200 SQ. MI. INDEX RAINFALL = 21.5 INCHES

6 HR. % FOR 20.9 SQ. MI. BASIN = 102 %
12 HR. % FOR 20.9 SQ. MI. BASIN = 115 %
24 HR. % FOR 20.9 SQ. MI. BASIN = 125 %
48 HR. % FOR 20.9 SQ. MI. BASIN = 134 %

SNYDER HYDROGRAPH COEFFICIENTS

DUE TO THE RATHER FLAT, SWAMPY NATURE OF THE DRAINAGE BASIN, AVERAGE COEFFICIENTS WILL NOT BE USED. INSTEAD, A HIGHER C_T VALUE WILL BE USED.

$C_T = 6.0$ $\qquad$ $C_p = 0.5$

$$T_p = C_T (L \cdot L_{CA})^{0.3}$$

WHERE L = LENGTH OF LONGEST DRAINAGE PATH, AND
L_{CA} = LENGTH OF DRAINAGE PATH FROM THE BASIN CENTROID

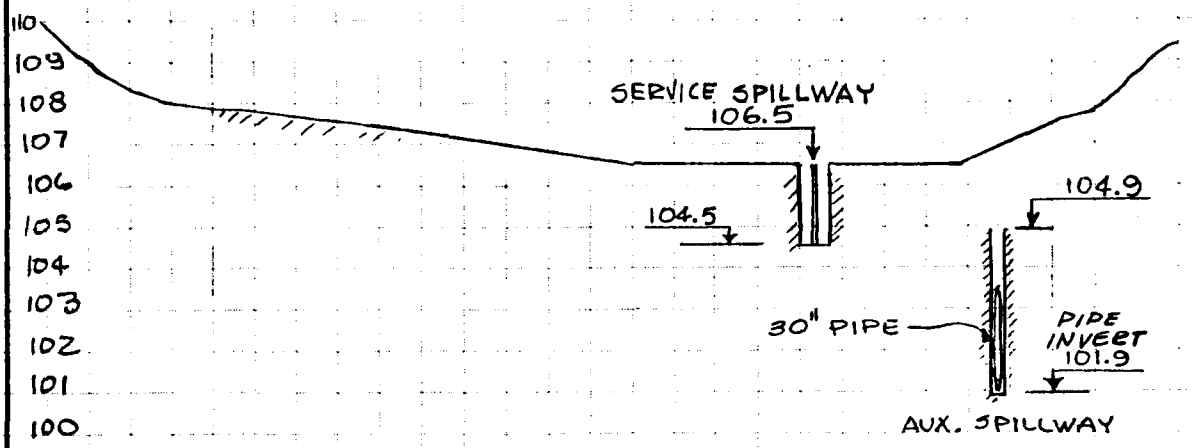
$L \approx 6.4$ MILES $\qquad$ $L_{CA} \approx 2.7$ MILES

$$T_p = 6.0 (6.4 \times 2.7)^{0.3} = 14.1 \text{ HOURS}$$

BRYANT ASSOCIATES, INC.
648 Beacon Street
BOSTON, MASSACHUSETTS 02215
(617) 247-1800

JOB DACW 33-80-C-0014
SHEET NO. D-3 OF
CALCULATED BY R.G. DATE 1/2/80
CHECKED BY RPB DATE
SCALE

BOLIVAR POND DAM HEH



STAGE DISCHARGE

H=0 @ SPILLWAY CREST, ELEVATION 106.5
AUX. SPILLWAY " 104.9
C= 2.8 TOP OF DAM Q_3
C= 3.1 SERVICE SPILLWAY $Q_1 = 2LCH^{1.5}$

THE AUX. SPILLWAY IS CONSIDERED SUBMERGED, THE 30" PIPE, AS AN ORIFICE FOR OUTFLOW COMPS.

Q_2 [1] = $5.37 \times \pi 2.5^2/4 \times d^{0.5}$

d IS THE DEPTH OF WATER ABOVE THE CENTROID OF THE PIPE

[1] REFER TO PAGES 12-26 & 12-27, U.S. DOT. FED. HIGHWAY ADMIN. HYDRAULIC ENG'R. CIRCULAR #12

ELEVATION MSL	H Ft.	SERV. SPILLWAY Q_1 CFS	AUX SPWY Q_2 CFS	TOP WIDTH OF FLOW Ft.	FLOW OVER TOP OF DAM Q_3 CFS	TOTAL CFS (EXCLUDING OVERTOPPING)
104.5	0	0	0			0
104.9	0.4	6	0			6
105.5	1	24	40			64
106.5	2	67	48	420		115
107.5	3	123	55	580		178
108.5	4	190	61	750		251
109.5	5	265	66	770		331
110.5	6	349	71	990		420
112.0	7.5	490	79	1010		569
114.0	9.5	700	87	1060		787
116.0	11.5	930	95	1130		1025
118.0	13.5	1190	102	1160		1292

Flow over top of dam handled by #7 & #8 W.V. cards of HEC-1 2 cfs safety.

BRYANT ASSOCIATES, INC.
648 Beacon Street
BOSTON, MASSACHUSETTS 02215
(617) 247-1800

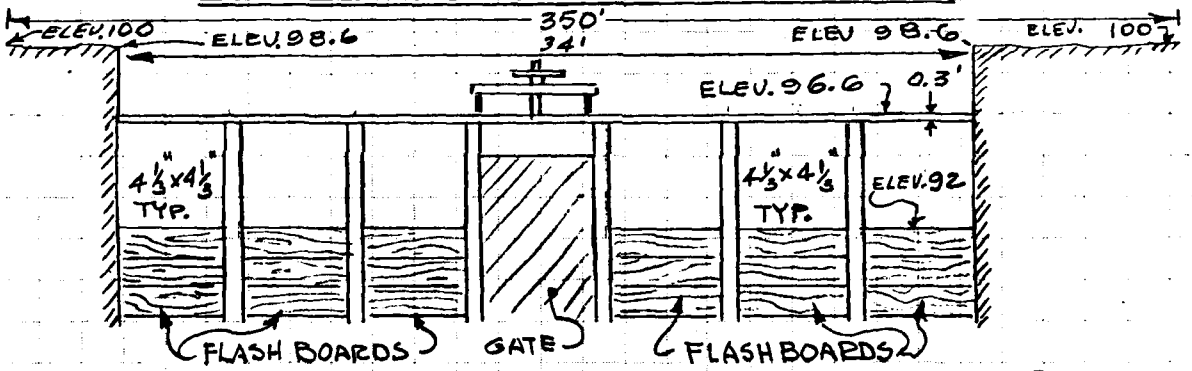
JOB DACW33-80-C-0014
SHEET NO. D-4 OF
CALCULATED BY R.G. DATE 1/2/80
CHECKED BY RRB DATE
SCALE

BOLIVAR POND DAM H&H

STAGE STORAGE

	ELEVATION (MSL)	AREA (AC)
	92.5	0
	94.5	6
SPILLWAY CREST	104.5	23
TOP DAM LOW PT.	106.5	38
	110.0	140
	120.0	305

FORGE POND DAM STAGE DISCHARGE



H = 0 @ SPILLWAY CREST — ELEV. = 91

$C = 3.0$ $\begin{cases} Q_1 = 6 \times 4.23 \times 3 \times H^{1.5} & H \leq 4.6 \\ Q_{1a} = 34 \times 3 \times (H-4.6)^{1.5} + Q_1 a & 4.6 < H < 6.6 \end{cases}$

TOP OF DAM $C = 2.8$

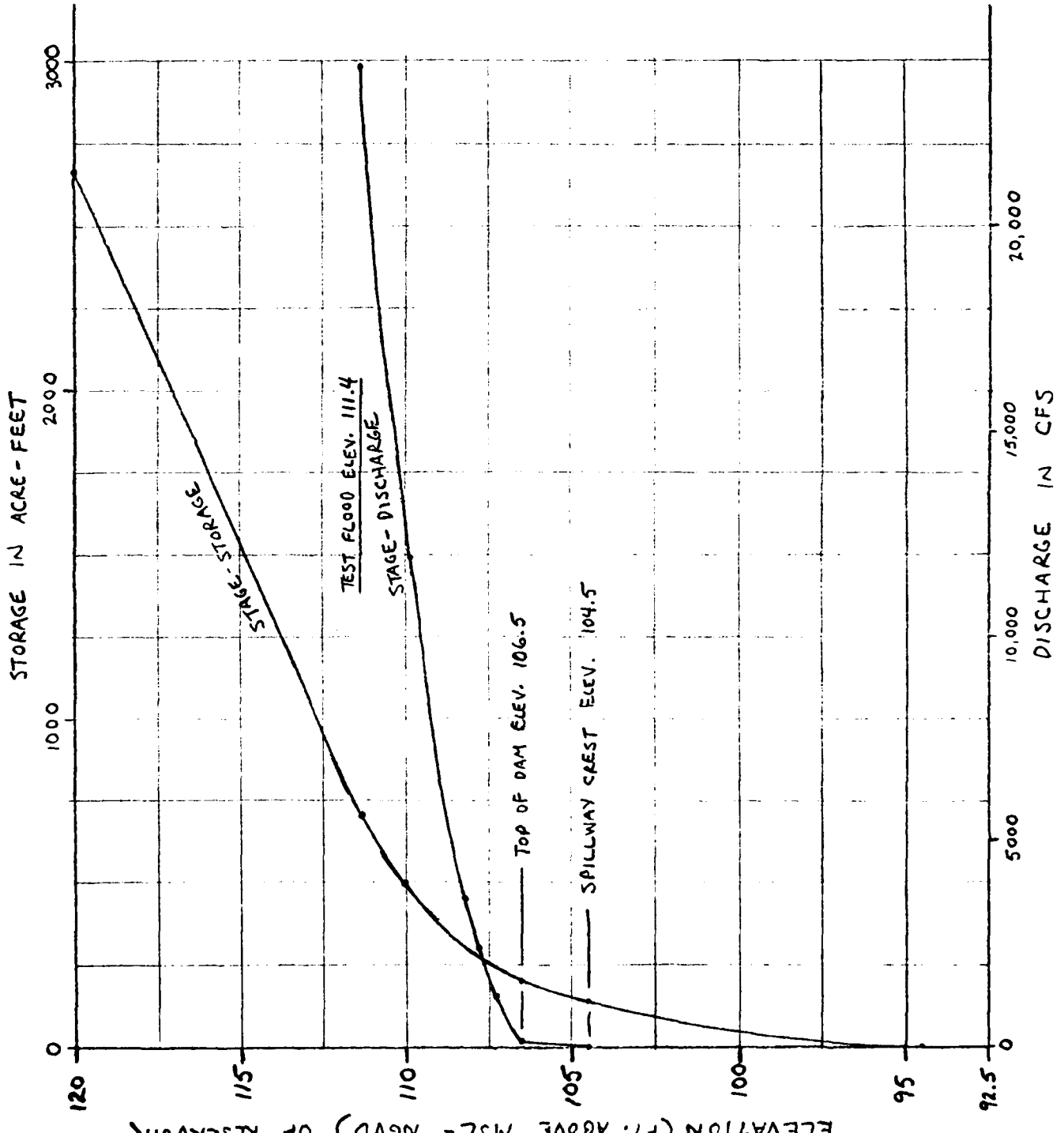
ELEVATION MSL	H Ft.	SPILLWAY CFS	TOP OF DAM CFS	ΣQ CFS
92.0	0	0		
94.0	2	220		220
96.0	4	624		624
96.6	4.6	769		769
98.0	6	938		938
98.6	6.6	1,057	0	1,057
100.0	8	1,408	812	2,220

SURCHARGE STORAGE

NORMAL POOL ELEV. 92 AREA = 29 AC.
" 100 " = 99 AC.

O'BRIEN & GERE
ENGINEERS, INC.

SUBJECT	SHEET	BY	DATE	JOB NO
STAGE - STORAGE & STAGE - DISCHARGE CURVES	D-5	RRB		



FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 26 FEB 79

BOLIVAR POND DAM FLOOD ROUTINGS
WITHOUT BREACHING

INPUT

```
     1          A1                   HYDROLOGIC ANALYSIS OF BOLIVAR POND DAM
     2          A2                   NATIONAL DAM INSPECTION PROGRAM
     3          A3                   NEW ENGLAND DIVISION - CORPS OF ENGINEERS
     4          A    300       0      15       0       0       0       0       0      -4       0
     5          B1     5
     6          J      1       5       1
     7          J1   .05      .1      .15      .5     1.0
     8          K      0  INFLOW                                    1
     9          K1                  INFLOW TO BOLIVAR POND
    10          M      1       1    20.9                                                  1
    11          P      0    20.9     102     115     125     134
    12          T                                                   0    0.05
    13          W   14.1     0.5
    14          X   -1.7    -0.1       2
    15          K      1  BOLIV                                    1
    16          K1                  ROUTED OUTFLOW FROM BOLIVAR POND
    17          Y                                   1       1
    18          Y1     1                                                -104.5      -1
    19          Y4 104.5   104.9   105.5   106.5   107.5   108.5   109.5   110.5     114     118
    20          Y5     0       6      64     115     178     251     331     420     787    1292
    21          YA     0       6      23      38     140     305
    22          YC  92.5    94.5   104.5   106.5     110     120
    23          YS 104.5
    24          YD 106.5     2.8     1.5    1160
    25          YL     0     420     580     750     770     990    1010    1060    1130    1160
    26          YV 106.5   106.6   107.5   108.5   109.5   110.5     112     114     116     118
    27          K     99
```

D-6

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**************************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION        JULY 1978
LAST MODIFICATION  26 FEB 79
**************************************

RUN  DATE= 03/12/80.
     TIME= 08.47.49.

                    HYDROLOGIC ANALYSIS OF BOLIVAR POND DAM
                    NATIONAL DAM INSPECTION PROGRAM
                    NEW ENGLAND DIVISION - CORPS OF ENGINEERS

                                  JOB SPECIFICATION
         NQ     NHR    NMIN    IDAY     IHR    IMIN   METRC    IPLT    IPRT   NSTAN
        300       0      15       0       0       0       0       0      -4       0
                                JOPER     NWT   LROPT   TRACE
                                    5       0       0       0

                        MULTI-PLAN ANALYSES TO BE PERFORMED
                             NPLAN= 1 NRTIO= 5 LRTIO= 1
PERCENTAGES OF PMF -> RTIOS=   .05    .10    .15    .50   1.00

   **********     **********     **********     **********     **********

INFLOW HYDROGRAPH              SUB-AREA RUNOFF COMPUTATION
DEVELOPMENT
                              INFLOW TO BOLIVAR POND

                       ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                      INFLOW       0       0       0       0       0       1       0       0

                                    HYDROGRAPH DATA
          IHYDG   IUHG   TAREA    SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
              1      1   20.90    0.00   20.90    0.00   0.000       0       1       0

                                      PRECIP DATA
                 SPFE     PMS      R6     R12     R24     R48     R72     R96
                 0.00   20.90  102.00  115.00  125.00  134.00    0.00    0.00
 TRSPC COMPUTED BY THE PROGRAM IS  .824

                                       LOSS DATA
     LROPT   STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
         0    0.00    0.00    1.00    0.00    0.00    1.00    0.00     .05    0.00    0.00

                                 UNIT HYDROGRAPH DATA
                           TP= 14.10    CP= .50     NTA=  0

                                    RECESSION DATA
                        STRTQ=   -1.70     QRCSN=    -.10     RTIOR= 2.00

        UNIT HYDROGRAPH100 END-OF-PERIOD ORDINATES, LAG= 14.13 HOURS, CP= .50  VOL= .60
           1.       4.       9.      15.      21.      29.      36.      45.      54.      63.
          73.      83.      94.     105.     116.     128.     140.     152.     164.     177.
         190.     203.     216.     229.     243.     257.     270.     284.     299.     313.
         327.     340.     353.     365.     377.     388.     399.     409.     419.     428.
         437.     445.     453.     460.     467.     473.     479.     484.     488.     492.

         495.     497.     499.     500.     500.     500.     498.     495.     489.     483.
         477.     470.     464.     458.     452.     446.     440.     435.     429.     423.
         418.     412.     407.     402.     396.     391.     386.     381.     376.     371.
         366.     362.     357.     352.     348.     343.     339.     334.     330.     325.
         321.     317.     313.     309.     305.     301.     297.     293.     289.     285.

       0                                  END-OF-PERIOD FLOW
   MO.DA  HR.MN  PERIOD   RAIN   EXCS   LOSS   COMP Q      MO.DA  HR.MN  PERIOD   RAIN   EXCS   LOSS   COMP Q

                                                                          SUM  23.09  21.30   1.79  697263.
                                                                              ( 586.)( 541.)(  45.)(19744.29)
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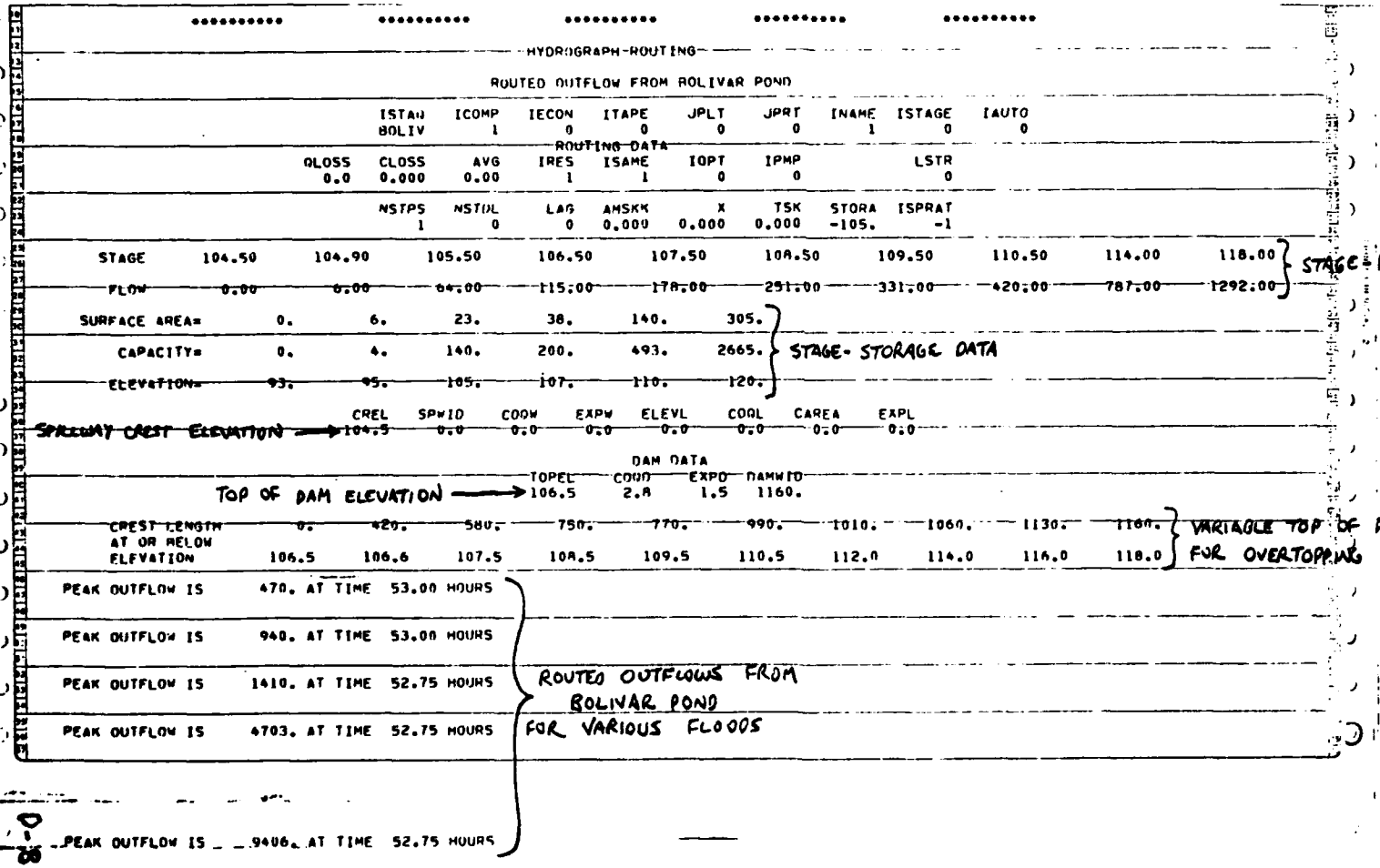

HYDROGRAPH-ROUTING

ROUTED OUTFLOW FROM BOLIVAR POND

ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
BOLIV	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-105.	-1

STAGE	104.50	104.90	105.50	106.50	107.50	108.50	109.50	110.50	114.00	118.00
FLOW	0.00	0.00	64.00	115.00	178.00	251.00	331.00	420.00	787.00	1292.00

STAGE-DISCHARGE DATA

SURFACE AREA=	0.	6.	23.	38.	140.	305.
CAPACITY=	0.	4.	140.	200.	493.	2665.
ELEVATION=	93.	95.	105.	107.	110.	120.

STAGE-STORAGE DATA

SPILLWAY CREST ELEVATION → CREL = 104.5

SPWID	COOW	EXPW	ELEVL	COOL	CAREA	EXPL
0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOP OF DAM ELEVATION → TOPEL = 106.5

COOD	EXPD	DAMWID
2.8	1.5	1160.

CREST LENGTH AT OR BELOW ELEVATION										
	0.	420.	580.	750.	770.	990.	1010.	1060.	1130.	1160.
	106.5	106.6	107.5	108.5	109.5	110.5	112.0	114.0	116.0	118.0

VARIABLE TOP OF DAM ELEVATIONS - FOR OVERTOPPING DISCHARGE

PEAK OUTFLOW IS 470. AT TIME 53.00 HOURS

PEAK OUTFLOW IS 940. AT TIME 53.00 HOURS

PEAK OUTFLOW IS 1410. AT TIME 52.75 HOURS

PEAK OUTFLOW IS 4703. AT TIME 52.75 HOURS

PEAK OUTFLOW IS 9406. AT TIME 52.75 HOURS

ROUTED OUTFLOWS FROM BOLIVAR POND FOR VARIOUS FLOODS

D-88

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 .05	RATIO 2 .10	RATIO 3 .15	RATIO 4 .50	RATIO 5 1.00	
HYDROGRAPH AT	INFLOW	20.90 (54.13)	1	471. (13.33)	941. (26.65)	1412. (39.98)	4706. (133.24)	9412. (266.52)	} PEAK INFLOWS
ROUTED TO	BOLIV	20.90 (54.13)	1	470. (13.30)	940. (26.62)	1410. (39.93)	4703. (133.17)	9406. (266.34)	} ROUTED OUTFLOWS

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	104.50	104.50	106.50
STORAGE	140.	140.	200.
OUTFLOW	0.	0.	115. → SPILLWAY DISCHARGE CAPACITY

RATIO OF PMP	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.05	106.94	.44	219.	470.	20.25	53.00	0.00
.10	107.22	.72	233.	940.	24.25	53.00	0.00
.15	107.45	.95	246.	1410.	27.50	52.75	0.00
.50	108.47	1.97	320.	4703.	46.25	52.75	0.00
1.00	109.43	2.93	419.	9406.	52.50	52.75	0.00

→ TEST FLOOD ELEVATION

→ ROUTED TEST FLOOD OUTFLOW

ROUTING BOLIVAR POND DAM BREACH FLOOD TO DOWNSTREAM DAMAGE AREA (SECONDARY)

INPUT

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**********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
**********************************
    1              A1
    2              A2
    3              A3
    4              R     150       0       30       0       0       0       0      -4       0
    5              M1      5
    6              J       2       1        1
    7              J1  .0001
    8              K       1   BOLIV                                       1
    9              M1
   10              Y                                   1       1
   11              Y1      1                                           -106.5      -1
   12              Y4  104.5   104.4   105.5   106.5   107.5   108.5   109.5   110.5     114     118
   13              Y5      0       6      64     115     176     251     331     420     787    1292
   14              $A      0       6      23      38     140     305
   15              $E   92.5    94.5   104.5   106.5     110     120
   16              $$  104.5
   17              $D  106.5     2.8     1.5    1160
   18              $L      0     420     580     750     770     940    1010    1060    1130    1160
   19              $V  106.5   106.4   107.5   108.5   109.5   110.5     112     114     116     118
   20              $M     80    0.01    94.5       2   106.5     130
   21              $M     80    0.01    94.5       2   106.5   106.5
   22              K       1   FPOND                                       1
   23              M1
   24              Y                                   1       1
   25              Y1      1                                             -92      -1
   26              Y4     92      94      96    96.6      96    98.6     100
   27              Y5      0     220     624     769     936    1057    2220
   28              $A     29      94
   29              $E     92     100
   30              $$     92
   31              $D    100
   32              K     99
```

HYDROLOGIC ANALYSIS OF BOLIVAR POND DAM
NATIONAL DAM INSPECTION PROGRAM
NEW ENGLAND DIVISION - CORPS OF ENGINEERS

ROUTED OUTFLOW FROM BOLIVAR POND

BOLIVAR POND BREACH THROUGH FORGE POND

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
**********

RUN  DATE= 01/29/80.
     TIME= 08.53.37.
```

HYDROLOGIC ANALYSIS OF BOLIVAR POND DAM
NATIONAL DAM INSPECTION PROGRAM
NEW ENGLAND DIVISION - CORPS OF ENGINEERS

JOB SPECIFICATION

NO.	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
150	0	30	0	0	0	0	0	-4	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 2 NRTIO= 1 LRTIO= 1

NO INFLOW → RTIOS= .00

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

ROUTED OUTFLOW FROM BOLIVAR POND

ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
BOLIV	1	0	0	0	0	1	0	0

ALL PLANS HAVE SAME ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTOL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-107.	-1

SPILLWAY DISCHARGE

STAGE	104.50	104.90	105.50	106.50	107.50	108.50	109.50	110.50	11 .00	118.00
FLOW	0.00	5.00	64.00	115.00	178.00	251.00	331.00	420.00	78 .00	1292.00

STAGE-STORAGE DATA

SURFACE AREA=	0.	6.	23.	35.	140.	305.
CAPACITY=	0.	4.	140.	200.	493.	2565.
ELEVATION=	93.	95.	105.	107.	110.	120.

CREL	SPWID	COOW	EXPW	ELEVL	COOL	CAREA	EXPL
104.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TOP OF DAM ELEVATIONS

DAM DATA

TOPEL	COOD	EXPD	DAMWID
106.5	2.8	1.5	1160.

CREST LENGTH (IN FEET) AT OR BELOW ELEVATION	0.	420.	580.	750.	770.	990.	1010.	1060.	1130.	1 60.
	106.5	106.6	107.5	108.5	109.5	110.5	112.0	114.0	116.0	1 8.0

DAM BREACH DATA

BRWID	Z	ELBM	TFAIL	WSEL	FAILEL
80.	.01	94.50	2.00	106.50	130.00

BREACH DIMENSIONS (NO FAILURE OCCURS)

PEAK OUTFLOW IS 115. AT TIME 0.00 HOURS

DAM BREACH DATA

BRWID	Z	ELBM	TFAIL	WSEL	FAILEL
80.	.01	94.50	2.00	106.50	106.50

BREACH DIMENSIONS (FAILURE BEGINS IMMEDIATELY WITH RESERVOIR SURFACE @ TOP OF DAM)

BEGIN DAM FAILURE AT 0.00 HOURS

PEAK OUTFLOW IS 1495. AT TIME 1.00 HOURS

HYDROGRAPH ROUTING

BOLIVAR POND BREACH THROUGH FORGE POND

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
FPOND	1	0	0	0	0	1	0	0

ALL PLANS HAVE SAME ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-92.	-1

FORGE POND
SPILLWAY DISCHARGE

STAGE	92.00	94.00	96.00	96.60	98.00	98.60	100.00
FLOW	0.00	220.00	624.00	769.00	938.00	1057.00	2220.00

SURFACE AREA=	29.	99.
CAPACITY=	0.	484.
ELEVATION=	92.	100.

} STAGE - STORAGE DATA

CREL	SPWID	COOW	EXPW	ELEVL	COOL	CAREA	EXPL
92.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COOD	EXPD	DAMWID
100.0	0.0	0.0	0.

PEAK OUTFLOW IS 61. AT TIME 5.00 HOURS
WITH NO BREACH

PEAK OUTFLOW IS 541. AT TIME 2.00 HOURS
WITH BREACH

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1
				.00
ROUTED TO	ROLIV	0.00	1	109.
		(0.00)		(3.09)
			2	1489.
				(42.16)
ROUTED TO	FPOND	0.00	1	91.
		(0.00)		(1.73)
			2	541.
				(15.31)

- ROUTED OUTFLOW WITHOUT BREACH
- ROUTED OUTFLOW WITH BREACH
- FORGE POND ROUTED OUTFLOW WITHOUT BREACH
- FORGE POND ROUTED OUTFLOW WITH BREACH

COMPARISON OF BREACH AND NON-BREACH FLOWS AT BOLIVAR POND

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	106.50	104.50	106.50
STORAGE	200.	140.	200.
OUTFLOW	115.	0.	115.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.00	106.36	0.00	200.	115.	0.00	0.00	0.00

PLAN 2 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	106.50	104.50	106.50
STORAGE	200.	140.	200.
OUTFLOW	115.	0.	115.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.00	106.49	0.00	200.	1495.	0.00	1.08	0.00

COMPARISON OF BREACH AND NON-BREACH FLOWS AT FORGE POND

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	92.00	92.00	100.00
STORAGE	0.	0.	484.
OUTFLOW	0.	0.	2220.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.00	92.56	0.00	17.	61.	0.00	5.00	0.00

PLAN 2 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	92.00	92.00	100.00
STORAGE	0.	0.	484.
OUTFLOW	0.	0.	2220.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.00	95.59	0.00	144.	561.	0.00	2.00	0.00

APPENDIX E

INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS

END

DATE
FILMED

8 -85